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THE GERMAN CRUISER SCHWALBE.

THE cruisers of the German navy are large gunboats designed specially for carrying the German flag into foreign waters and for protecting German trade in the waters of China and Japan, etc., as well as of the German possessions outside of Europe, and that they may be better suited for this purpose, they are of proportionately light draught, thus being enabled to enter small harbors and run as far as possible up shallow rivers.

As vessels of this class carry smaller crews and have less powerful engines, their running expenses are considerably less than those of corvette cruisers and frigate cruisers, which have hitherto been used as cruisers in the waters referred to. There had been five vessels of this latter class in the German navy, viz., the Albatross, Nautilus, Habicht, Möve, and the Adler, and last year the sixth, the Schwalbe, was added to their number.

The new cruiser differs from other vessels of its class chiefly in the form of its hull, at the stem, and in the small amount of rigging, which is to be used only in case of need. The lines of the vessel are in every way more slender and pleasing than those of the five older ships, and for this reason the expectation that the Schwalbe would have greater speed and seaworthiness will be realized. The stern is round, as in the other vessels of this class, while the bow is considerably drawn in above and ends in the form of a ram under water, thus resembling the large ironclads. It is rigged as a three-masted schooner.

The principal measurements are as follows: the greatest length is about 219 ft., greatest width about 31 ft., depth of hold 16 ft., and the draught, when loaded, 14 ft. The displacement with this draught is about 1,230 tons.

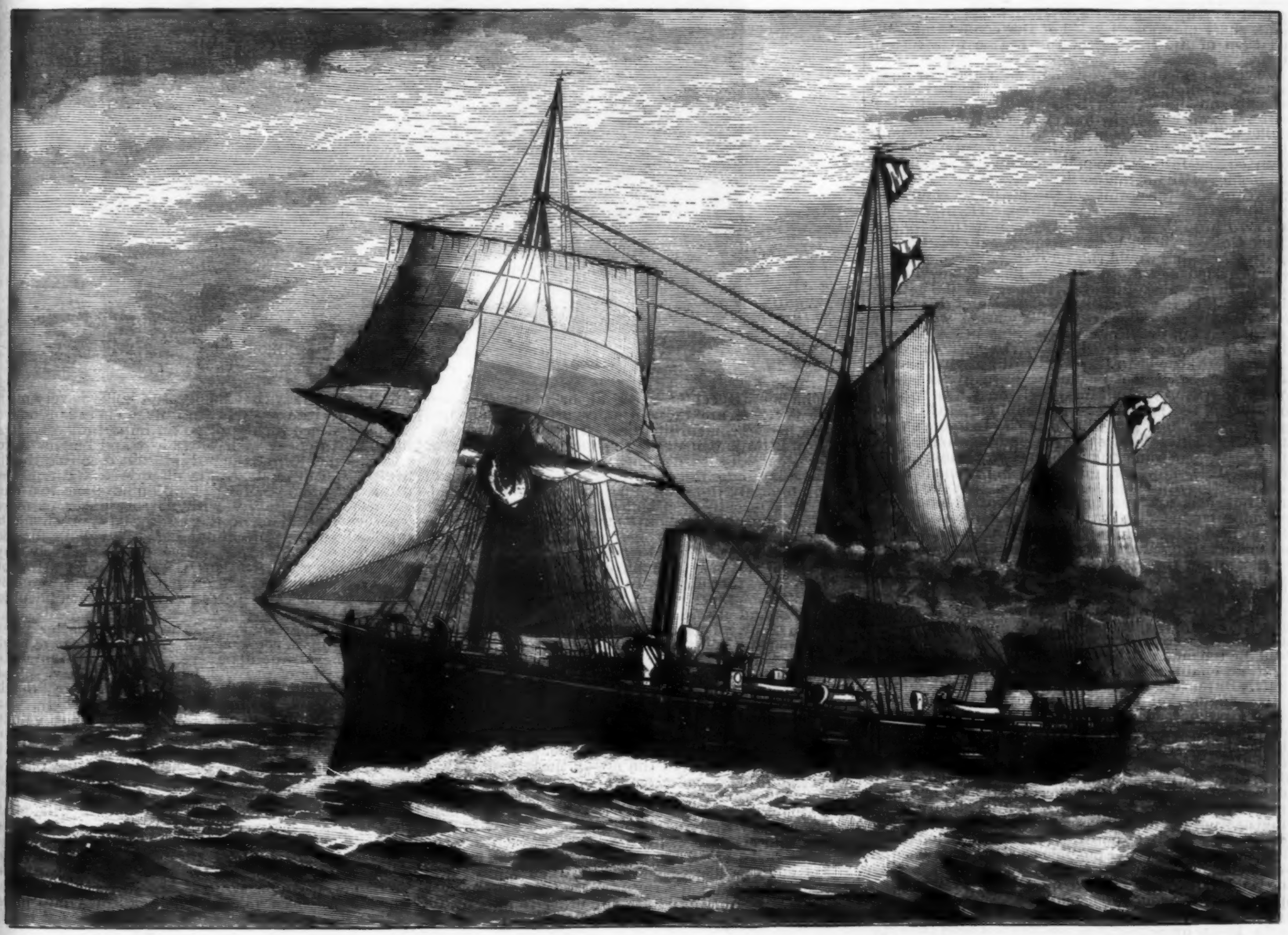
The armament consists of eight 10·5 centimeter guns of the newest construction and three 3·7 centimeter revolving cannon. Four of the heavy guns are placed in projecting turrets, two of which are built on each side of the vessel, so that they can be fired fore and aft in the direction of the keel, giving these four cannon a very wide range. The four other cannon are placed at broadside ports. The 3·7 centimeter cannon are so arranged that the gunners will not be exposed to the fire and draught of the 10·5 guns during battle. Torpedo-projecting tubes are so placed as to work to the greatest advantage.

While the other cruisers of the German navy are single-screw propellers, the Schwalbe is provided with two screws. The two engines for driving these screws are two-cylinder compound engines with double acting connecting rods and surface condensers. The cylinders are provided with direct steam inlets. Each engine is placed in a separate water-tight compartment, and together they develop 1,500 indicated h. p., giving the vessel a speed of 14 knots. The boilers are also placed in separate water-tight compartments. They are of steel and will stand a pressure of seven atmospheres. Centrifugal ventilators are provided for supplying the necessary draught for the machinery.

The coal bunkers will hold about 260 tons, which is sufficient to last for several thousand miles, as the capacity of the engines is limited. The crew of 150 men is very well accommodated in the quarters set apart for them. The officers' and deck officers' quarters are in the rear, and those of the crew in the fore part of the between-decks.

Work on the cruiser was begun in July, 1886, on the imperial docks at Wilhelmshafen, and the work was pushed so that the vessel could be launched August 16 of last year. The cost of construction, inclusive of engines, boilers, rigging, and other equipments, is estimated at about $288,000, and the cost of the armament, etc., at about $78,000.

Since the middle of last year another cruiser has been in process of construction at the yards in Wilhelmshafen, from plans which are nearly the same as those used for the Schwalbe, but, as usual, the name of this vessel is withheld until after the launching.—*Illustrirte Zeitung.*



THE NEW GERMAN CRUISER SCHWALBE.

STEAM ENGINES FOR LONG RUNS.

IN our last impression we reproduced a paragraph from an American paper stating that a Westinghouse engine at the Pittsburg gas works has run continuously for thirteen months, making 500 revolutions per minute, or, in all, 233,000,000 of revolutions without stopping for a moment, and that it is still running. This engine must have run at something less than 500 revolutions per minute, which would give in thirteen months 274,200,000 turns. But it is unnecessary to split hairs about what is, if the statement be true, a unique performance. Naturally the story will be received with a certain amount of incredulity. After all, however, it does not involve any physical impossibility. It may serve as a text on which to hang a discussion of the causes which militate against the making of long continuous runs by steam engines. Theoretically, there is no reason why a steam engine having made one revolution should not make another; and on the doctrine of probabilities, it may be argued that if an engine has made a million of revolutions without stopping, the chances are a million to one that it will make another, and so on. But we know that, in practice, steam engines cannot go on working forever; and it is our purpose just now to consider why a time must come when they will have to stop.

The forces fighting, so to speak, against the engine may be readily summarized. In the first place, the various parts of the engine are exposed to stresses constantly varying in direction and amount; in the second place, there are numerous rubbing surfaces which cannot work absolutely without friction, and which are consequently liable to wear away; lastly, there are concussive shocks or impacts which tend to cause deformation of the parts which come into contact. As a steam engine, unlike a living organism, possesses no intrinsic recuperative powers, its parts must ultimately either break, wear out, or lose their shape, the end being the same in any case, viz., the stopping of the machine for repairs. According to the

conditions observed in constructing and working the engine, a continuous run made by it will be long or short. We may consider these conditions *seriatim*. One of the first and most important is, that the crank shaft shall be made of the best metal and be very lightly loaded. It is not as generally known as it ought to be that there is no such thing as a bar of metal which will not yield to a small stress imposed on it. A railway axle 4 in. in diameter can be bent by an amount which it is possible to measure, by weight of 100 lb. hung in the middle. A crank shaft therefore, especially of the double-web type, will be bent through a sensible amount at each revolution; and it has been shown over and over again that the duration of a crank shaft, say, in a locomotive engine, depends, other things being equal, on the amount to which it is bent at each revolution, the quality of its material, and the number of bendings. The process by which fracture is ultimately brought about is in its nature precisely the same as that by which we break a bit of wire or tin by bending either backward and forward between our fingers. Now the crank shaft of the Westinghouse engine at the Pittsburg gas works must have been bent first one way and then the other no less than 466,000,000 of times; and that it should endure this manipulation it is essential that the stress on it should be very small, so that the bending should be trifling. We are told that the engine is 10 horse power, but we are not told what it was indicating. Assuming that the stroke was 6 in., the piston speed would be about 250 ft. per minute, and there are two pistons, the engine being compound; this gives an average pressure of 660 lb. on each piston for 10 horse power. But the stress at the beginning of each stroke must have been much greater than this—probably three times as much—quite enough to produce an easily measurable bending of a 2½ in. shaft. Therefore we can only say that the piece of steel which endured nearly five hundred millions of contrary deflections is of exceptional quality and worthy of all praise. What holds good of the crank shaft may also be said of the connecting rods, and even of the framing of the engine to a certain extent.

We come next to the question of wear and tear in an engine. Assuming that it is made with pistons all through, no slide valves being used, it is entirely a matter of workmanship and material how long the engine will run, always presupposing that the steam is quite clean, and the lubrication uniformly efficient. In an engine intended to make long runs, the pistons and insides of the cylinders must be got up with elaborate care, and the springs of the piston rings must be so adjusted that these last shall press as lightly as will suffice to keep them steam-tight against the cylinder. Theoretically, a solid block piston got up dead steam-tight by scraping would run forever without wear and tear, provided grit and dust were kept out of the cylinder. In practice, however, it is essential that the piston shall be in some measure elastic, and this means that there must be friction. In marine work it is known that tail rods are of much value in saving both piston and cylinder from wear. English engineers have something yet to learn concerning cylinders and pistons from such men as Vanden Kerchove of Ghent, concerning whose admirable work we wrote fully at the time of the last Antwerp exhibition. All things considered, we hold that it is more easy to make pistons and piston valves and cylinders endure through tremendously long runs than any other portion of the engine. It is, however, quite possible to make a mistake in fitting up these parts of an engine, less in degree, but somewhat similar in kind, to the blunder of a sea-going engineer in the old low-pressure days, who set out his piston rings so tight that, as tradition goes, his engines stopped dead when he was 100 miles out of port, because the metal scraped by the rings off the cylinder had accumulated to such an extent on the lower cylinder cover that the crank could not turn the center. The crank shaft and connecting-rod brasses offer a far more perplexing problem. They constitute, after all, the crux for the engineer. It would not, indeed, be too much to say that if they could be kept all right, an engine might be run until it broke its crank shaft. But no one has succeeded in producing a double-acting engine yet of which this can be said. Many years have now elapsed since we pointed out that if a high speed steam engine was to be a success, it must be single-acting. At that time no single-acting engines were being made. By a coincidence, a very short time after the appearance of our proposition, single-acting high-speed engines made their appearance, and their success justifies our argument. It is possible to run a single-acting engine with slack brasses, for the very obvious reason that the stress is always exerted in one direction. But it is not possible to run a double-acting engine unless the brasses are just the right fit, neither too slack nor too loose, and unfortunately what is a splendid adjustment when cold may be an adjustment anything but splendid if the crank pin heats a very little. In our own experience we once met with an engine indicating about 200 horse power, the main shaft of which would always run cool if the engine room door—which was close to it—were kept open, but it always heated when the door was shut. Lastly, we have to consider the effects of impact. If the engine is properly made and has sufficient lead, there will be no knocking or thumping so long as the brasses are in good condition and a proper fit; but the moment knock begins to make itself heard, we feel that we are approaching the moment when the engine must be stopped that the big ends may be adjusted. In large engines the effect of knock may be to crack the brasses, and in any case to hammer them out of shape by degrees; and in small engines much the same results may ensue, only they will be longer coming about.

To sum up, we may say that the destructive forces tending to render a long run difficult or impossible can all be fought against to a greater or less degree. That is to say, it is not impossible to build and work a steam engine, which can run day and night without ceasing for months, or even for years; but to secure such a result unusual precautions must be taken in selecting the design and materials, and to secure perfect workmanship. It is a mistake often made that nothing more is wanted than plenty of surface. Too much surface, if badly fitted and badly lubricated, may be much worse than too little surface. We could name a pair of large stationary engines built to drive electric light plant, and provided with enormous surface, which gave for the first couple of months of their existence constant trouble. They have long since been superseded by much smaller engines of a different type, which give no trouble at all. The large engines are kept as reserves. A notable case occurred in the United States navy some years ago. In order to provide plenty of bearing surface, the crank shaft was carried in brasses 4 ft. long, the shaft being about 13 in. in diameter; all the resources of the engine room could not keep these bearings cool, and they had ultimately to be reduced in length one-half. It is not given to every engineer to be able to build an engine which can make very long runs without stopping for adjustment, and it is questionable after all whether such an engine is worth the trouble and labor spent on it. But the fact that the Westinghouse engine company has contrived to produce such an engine as that at the Pittsburg gas works ought to act as a stimulus to our own builders of high-speed engines, who will certainly have to look to their laurels in the face of a continuous run of 233,000,000 of revolutions.—*The Engineer*.

SIBLEY COLLEGE LECTURES.—1887-88.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

IV.—Deterioration of Steam Boilers—Wear and Tear.

By J. M. Allen, M.E., Hartford, Conn.

When a boiler is completed and set to work, destructive forces more or less severe become active, and they must be carefully watched, or the working age of the boiler will be materially shortened. The forces may be mechanical or chemical, or both. The mechanical forces are those usually arising from bad design, bad workmanship in construction, with the exercise of little judgment in the matter of setting. A boiler should be so designed, constructed, and supported, that under the conditions of use the strains will be as uniformly distributed as the conditions will allow. In externally fired boilers it is well known that the bottom or fire sheets are more expanded than the top sheets. Hence it becomes necessary to have such arrangements made in the setting or support that the boiler shall rest easy and have opportunity to adjust itself to these conditions. In long cylinder boilers this strain often becomes quite severe, and if the boiler is tightly bound up in brickwork, fractures are very liable to occur. To compensate for this, various plans for supporting long boilers have been devised. In some cases the brackets or beams supporting the boilers have rested on volute springs, in other cases equalizing beams or bars are used. In some cases quite elaborate apparatus has been devised. The point to be attained is to so support the boiler that the load will be properly distributed under the changes of form to which the boiler may be liable under heat. Were it not for the elasticity of the metal, these long boilers could not adjust themselves to this severe strain, but when well constructed and properly set, they have stood the test for many years. Usually these long boilers, from forty to sixty feet in length, are used in iron works, and are heated by the waste gases from the smelting furnaces. The gas enters the boiler furnace under more or less pressure, and when ignited will present one continuous sheet of flame from the furnace to the rear end of the boiler. In order to fully utilize these gases, the long boilers are used. It is a question whether shorter boilers of a different type may not be used with safety and equal economy. Another form of cylinder boiler from twenty-eight to thirty feet long is used in connection with reheating furnaces in iron works, the gases being utilized for fuel. These boilers are often supported by resting simply on walls at each end. When the metal is being run off, the furnace doors are thrown wide open and a current of cold air is allowed to flow into the furnace and along the bottom of the boiler. The walls are very hot, and the temperature of the steam and water in the boiler is that due to the pressure. The sudden cooling of the fire sheets causes contraction, and a severe strain is brought, especially on the girth seams. These not unfrequently crack from rivet hole to rivet hole, and in a number of cases I have known the boiler to break into two parts, each part flying off in opposite directions. Fig. 1.

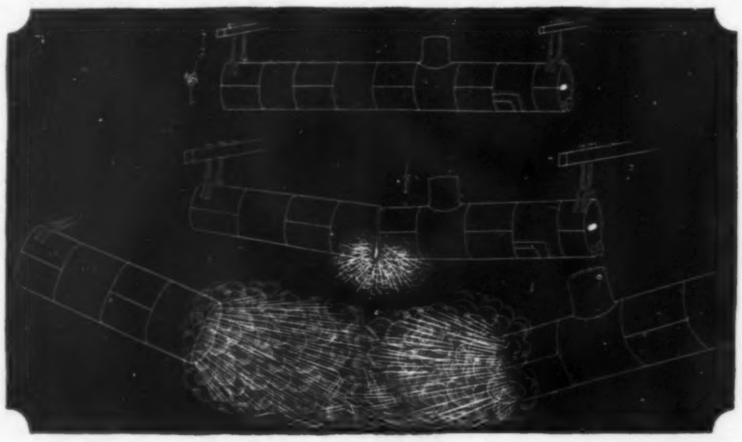


Fig. 1.

A current of cold air should never be allowed to strike, for any length of time, the fire sheets of a hot boiler, and such boilers should always have rods not less than one inch sectional area, running from head to head, sufficient in number to hold the boiler together under such circumstances. With this provision for safety, if a leak was noticed at any girth seam, the boiler could be put out of use and the extent of the fracture ascertained and suitable repairs made, thus preventing what otherwise might cause a serious accident.

Internally fired and fire box boilers have their weak points as well. There are narrow passages for the collection of sediment and formation of scale, and in these narrow passages the circulation is very imperfect, and wasting and corrosion is very liable to take place. I will, however, say that this type of boiler is very much used, and with economical results. There is economy of space also, which is often an important consideration. But boilers with water legs and narrow water passages should be frequently examined, so that the difficulty, if such exists, can be discovered and remedied before the progress of deterioration has gone to a dangerous extent. Boilers with narrow water passages, whether vertical or of the horizontal type, should be supplied with a sufficient number of hand holes to make the work of cleaning out sediment comparatively easy. The following illustrations (Figs. 2 and 3) will show how vertical boilers are often constructed, also how they should be constructed to overcome the difficulties mentioned.

Another important, yes, all important, matter is good workmanship in construction. If a boiler is bunglingly put together there will be severe local strains that under the conditions of use will be greatly aggravated. If the parts of the boiler do not fit well, and are brought into place by severe hammering and wrenching, what can we expect of such a boiler when put into use under a pressure of eighty or ninety pounds to the square inch? It will leak and give any amount of trouble to the user, and it will be fortunate if it does not burst or explode, carrying death and destruction in its flight. The "drift pin" seems to be one of the great evils in a boiler shop, although few boiler makers will admit that they use it, except to keep the plates in place while they are being riveted together. But I sometimes step into a boiler shop, unknown and unannounced, and I have seen the cruel use of the drift pin. Work has been poorly laid out, and the rivet holes which have been punched do not come into place, so that the holes in the different places are not coinci-

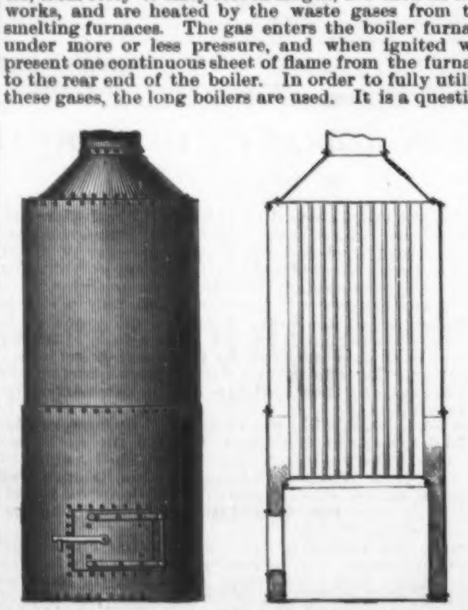


Fig. 2.—AS BOILERS ARE OFTEN BUILT.

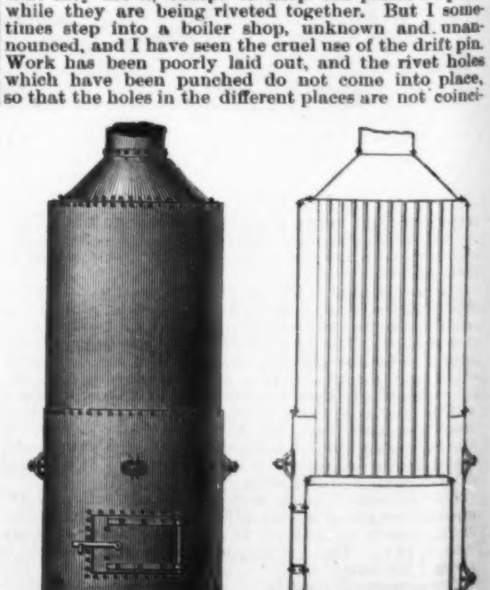


Fig. 3.—AS THEY SHOULD BE BUILT.

dent, one will ride over the other, and instead of using a reamer to cut away the intruding metal, the drift pin is resorted to, and strong men with hammers or sledges of eight pounds weight will drive the drift pin until one hole is elongated to a third or half greater than its original diameter. The rivet is driven and its expanded head covers the defect, and the exterior appearance of the boiler is very fair, but who can tell what strains and weaknesses have been caused, which, when the boiler is put into use, will develop into troublesome and possible dangerous defects? I am sometimes surprised that men will allow such work to go out of their shops. There is a moral responsibility connected with this business that should rest more heavily on some at least of the boiler makers in the country than their work would indicate, and in this connection allow me to say that a man's work is a pretty good indication of his character. Honesty and truthfulness lie at the very foundation of character, and these qualities show themselves in a man's life and work quite as much, yes, more, than in his words. Another potent cause of

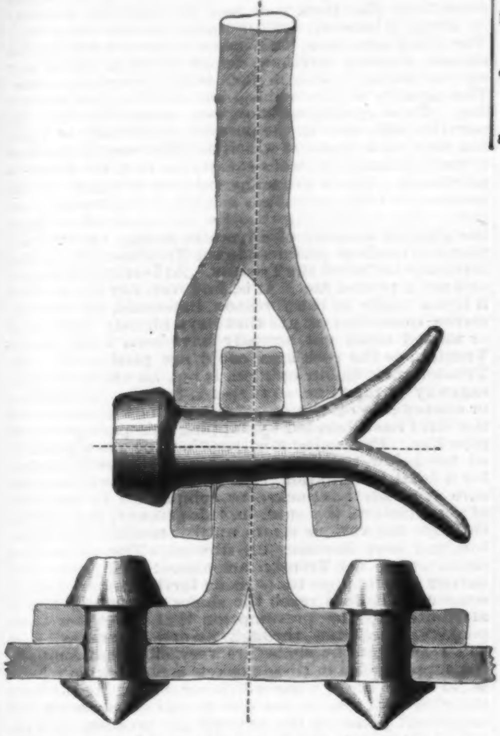


FIG. 4.—SHOWS A BRACE FASTENING TO HEAD OF BOILER AS THEY ARE SOMETIMES MADE. (This is no exaggeration.)

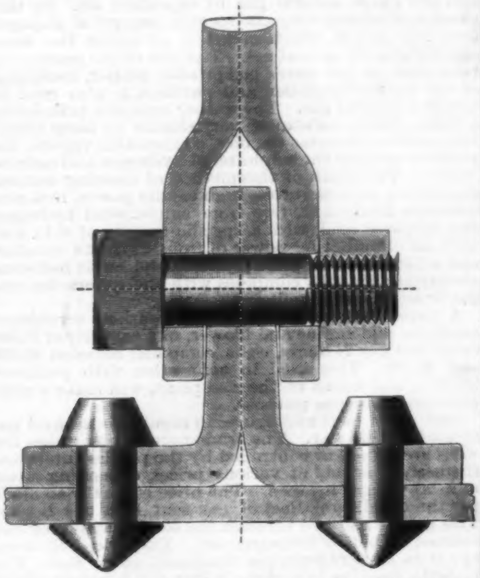


FIG. 5.—BRACE FASTENING AS IT SHOULD BE.

the deterioration of boilers is the water which is used causing deposits of sediment, formation of scale, and often having corrosive tendencies. We have a great variety of waters in this country, chemically speaking. In many sections of this country we find the underlying strata to be largely sulphate and carbonate of lime. This formation is of wider extent than any other. Then there are also chalybeate waters, magnesia, alumina, silicate, and waters carrying more or less organic matter. All of these waters give more or less trouble. In carbonate waters, the carbonate of lime and magnesia are frequently thrown down in the form of a fine powder, which settles along the joints at the lap; this often causes leaks. Another practice which aggravates these cases is returning the exhaust from the engine to the boiler. The oil thus carried into the boiler in combination with the impurities in the water makes a pasty substance that adheres to the plates, keeps the water from contact, causing overheating and often rupture. In fire box boilers where there are water legs and narrow water passages, this deposit often becomes a serious matter. Open heaters should not be used for collecting drips, if there is any oil used, but where the drips come from slashers or drying rooms, there will be no trouble. To utilize the heat in the exhaust from the engine, a pipe or coil heater should always be used. By such an apparatus all danger is avoided. I have mentioned above some qualities of water which are found in different sections of the country. In many cases the water is so bad that it is not fit to be used in boilers, and would not be used if a better supply could be found. Some very difficult problems come up for solution in connection with the water supply for boilers. Our rule is first to analyze the water, and then, knowing what impurities are carried in solution, we are better able to decide what the remedy must be. If the impurity is mainly carbonate of lime or magnesia, it is usually thrown down in the form of a fine powder. Frequent blowing is necessary, that is, blow down two gauges of water two or three times a day. This should be done in the morning before the mill or manufactory is started up, the impurities having had time to settle during the night. Then, again, after the dinner hour, just before starting the engine. This practice faithfully carried out will greatly relieve the difficulty. But in addition to this, there should be a good pipe or coil heater, and the sediment from that should blown out often. It sometimes occurs that the impurities do not readily settle on to the bottom of the boilers, especially if the boilers are hard worked, and circulation is rapid. In such cases a surface blow is desirable and important; the object being to remove, as far as possible, the impurities from the water. To give you a correct impression of the character of some waters used in boilers, I copied the following from our laboratory records: In a spring water from Nashville, Tenn., we found in 100,000 parts, insoluble and sparingly soluble solids 17·6 parts, readily soluble solid matter 35·2, or a total of 52·8 parts, or 30·83 grains to a United States gallon. In another case, water from a mill at a chemical works in Eastern New York, we found in 100,000 parts, insoluble and sparingly soluble solids 25·6, readily soluble solids 71·2, total 96·8 parts, or 56·32 grains in a United States gallon. In another case not far from Hartford, water from an artesian well, we found in 100,000 parts:

Insoluble and sparingly soluble........... 12·4
Readily soluble.............................. 32·4
Total 44·8 parts, or 26·15 grains in a U. S. gallon.

Similar waters have been found in artesian wells in different parts of the Connecticut Valley. This valley was once an ancient sea, long before the sandstone formation, and in boring deep wells strata are struck containing chloride of soda, sulphate of soda, carbonate of lime, also nitrate of potash. In some cases beds of Glauber's salt are struck, a sort of neutral sulphate of soda and very cathartic. This water, with care, could be used in a boiler, but frequent blowing would be imperative, also thorough cleaning at stated periods of at least once in two or three weeks.

We had occasion to analyze some water from a mine in Illinois, and found in 100,000 parts:

Insoluble and sparingly soluble..... 28·1 parts.
Readily soluble........................ 83·5 "
Total in 100,000 parts, 111·6, or 65·17 grains in a U. S. gallon.

This water had in addition to sulphuric and carbonate acids, and sulphureted hydrogen and nitric acids combined, chloride of soda, sulphate of soda, carbonate of lime, carbonate of soda, carbonate of potash, and carbonate of iron. It was wholly and utterly unfit for use in boilers. It would not only make a hard scale, but it was corrosive and would rapidly eat away the iron. An artesian well was bored in the vicinity of this mine, and was even worse than the mine water. Analysis showed:

Insoluble and sparingly soluble.... 26·4 parts.
Readily soluble........................ 231·2 "
Total in 100,000 parts, 257·6 parts.

This water, if used in a 60 horse power boiler, would deposit at least 250 pounds of sediment a week. It could not be safely used. I might continue this record over many pages, but it is sufficient to show the quality of some of the worst waters we have to deal with. You will very naturally inquire, What do you advise to be done in these cases of bad water? It is often a very puzzling question. If carbonate or sulphate of lime predominate, a very good antidote is carbonate of soda. Especially is this good in case of carbonate of lime. It prevents it from readily forming a scale, and if attention is given to blowing and cleaning, the difficulty can be easily overcome. We usually recommend from eight to ten pounds of soda ash dissolved in warm water to be introduced into the boiler about once or twice a week. This can be done by putting a branch into the suction pipe of the pump and connecting this branch by a hose to the pail or vessel containing the solution. In some cases we use one part, by weight, of catechu to two parts soda ash. Tannin works well in some cases, and a solution made from boiling the leaves of the eucalyptus tree has found much favor on the Pacific coast, and is being introduced in this part of the country. There is no grand panacea that will cure all these maladies. We must know something about the case before we can remove the disturbing cause. It will be readily seen that if attention is not given to these cases, the result will be not only annoying, but dangerous. Hard scale will accumulate on the fire plates of the boiler, resulting in overheating, and greatly weakening the boiler. The question of the waste of fuel is also an important one, for steam cannot be economically generated in a boiler where the plates are covered with scale. We all know that scale is a very slow conductor of heat, hence, in addition to the loss here, the plates are worn away and become greatly weakened. The question of corrosion is a serious one in some cases, and is difficult to manage. Water from swamp lands often has corrosive tendencies (Fig. 6), and in rivers and streams on which a number of manufactories are located, discharging their spent dyes and refuse, becomes very much contaminated, and gives serious trouble to the mills located down the stream. Law suits not unfrequently grow out of river contamination, and we have been summoned into court in a number of such cases. Our advice has always been for the parties to combine and lay a water main from the pond of the upper dam to the mill lowest down, of sufficient capacity to supply them all with good water. Another difficulty which is often encountered, and which at first seems paradoxical, is corrosion or pitting from pure water. Corrosion in boilers in the absence of free mineral acids can proceed from three principal causes:

1. The purity of the water.

Water is an almost universal solvent, and dissolves most substances to some extent. In the absence of substances in solution to prevent that action, even pure water would attack iron and corrode it, but except in the case of distilled (condensed) water returned to a boiler with the return pipe coming near the shell, this condition can hardly be said to exist, as even rain water contains from one to three parts per 100,000 of impurities.

2. The presence of air and dissolved gases in the water.

This is in all probability the most fruitful source of corrosion (except the acid decomposition of grease, oil, etc.). Water, unless recently boiled, contains varying amounts of dissolved gases, which are expelled at boiling temperatures. It has the peculiarity of holding a larger proportion of oxygen in solution than air has, usually about 33 per cent. more in water free from oxidizable matter. This under proper conditions would combine with the iron, rusting it rapidly, and when oxidation had once begun, forming a rust spot, heat and moisture would rapidly continue the work.

Water also contains varying and sometimes large amounts of carbonic acid gas. This by some authorities is equally injurious with the oxygen, but as when existing in large amounts it is almost invariably associated with lime and alkalies, which have been found to prevent corrosive action, in practice it is probably not especially harmful.

Oxygen and nitric acid occur in rain water and newly fallen snow, and the purer and more aerated a water is, as for example rain water, snow water, and water from uncultivated upland and quick slopes, the more dissolved oxygen it is likely to contain.

3. Substances in the water causing corrosion.

A water containing more than ten parts per 100,000 of solid matter usually contains considerable lime as carbonates, some soda and potash salts, and is alkaline. Such a water is not likely to corrode a boiler. A water with only four or five parts of solid matter (though it may contain also considerable dissolved oxygen, etc.) may be almost, if not quite, neutral, or even slightly acid. This acidity may come from dissolved organic matter, which if from fields or woody districts, the water is likely to carry in considerable amount. This woody extractive matter is easily decomposable, and some of the complex acids, so called humic, crenic, apocrenic, oxalic, etc., present, or formed under the action of decomposition, act very unfavorably on the iron of the boiler. This woody or especially peaty matter also contains tannic acid and gums in many cases, and has been observed to so varnish the inside of boilers in some places as effectually to prevent corrosion where otherwise it would be expected.

The presence of certain salts in solution has a very injurious effect on boilers, even in small amounts. Waters containing nitrates, and especially ammonia salts, as ammonia chloride, seem to be especially bad.

Water, therefore, exposed to the leaching from vaults, etc., is especially undesirable, even though a water strong in salt and alkalies from a common sewer might not be harmful to the boiler. The action of oil and tallow, etc., decomposing to oleic and margaric acid in the boiler, in the absence of alkalies, and especially

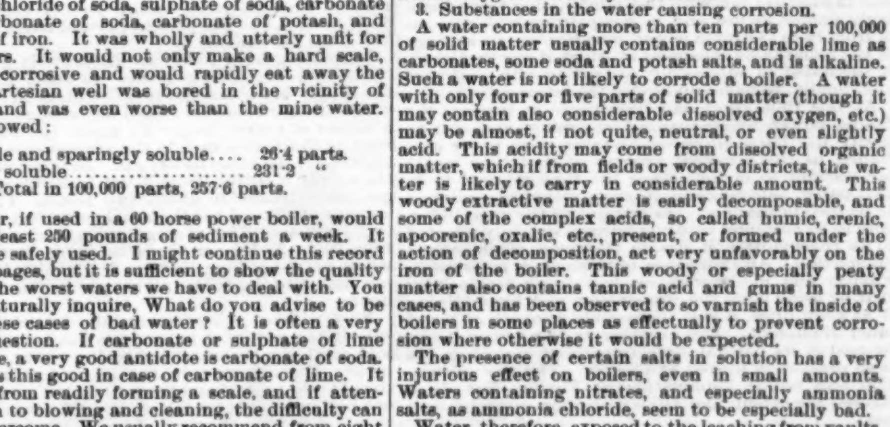


FIG. 6.—PART OF A HEAD OF A BOILER BADLY CORRODED AND PITTED BY WATER FROM A SWAMP.

with a coating of sulphate scale to prevent free circulation of the water at the corroding points, is well established.

It occurs, perhaps frequently, that a water at some seasons of the year making quite a scale is, at others, quite soft and charged with air and gases and partly dissolves that scale. This may go on indefinitely, until an unusually wet season, or a very clean or new boiler with the water quite pure, may suddenly develop injurious pitting from the absence of matter to counteract the effect.

FROM ROWAN—PART OF A TABLE BY WAGNER.

Iron, loss of weight in per cent. in water.

	One week.	Six weeks.
Distilled water (flask half filled)	0·44	2·46
Distilled water (*i. e.*, more air)	1·01	5·18
With magnesia chloride	1·31	3·05
With soda and potash chlorides	0·84	3·41
With ammonium chloride	1·15	4·16
With potash	0	0
With soda carbonate	0	0

I have now given you some of the causes that result in the wear and tear and deterioration of boilers. The subject is an important one, and the young consulting engineer will often find himself greatly puzzled to ascertain the true cause of the difficulty. He must not only be familiar with the true principles of construction and setting of boilers, so that wear and tear shall not result from unnecessary and undue strains, but he must know something of the sources of the water supply. A general knowledge of the geology of the country will be helpful. I believe that the broader a man's culture is, the more valuable his services will be. While technical education is all important, and without it the great problems which are so intimately connected with our growing industries could not be solved, a man need not be always in a rut. Another point. We have been considering the question of wear and tear as applied to steam boilers. The ambitious and industrious young engineer is in danger of being so absorbed in his profession as to forget himself, I mean his physical condition, his health. In testing metals we learn that there is a point known as the limit of elasticity. Beyond that is the permanent set, from which there is no recovery. Bear in mind that human fiber may be subjected to a strain that exceeds the elastic limit. Hence, I repeat, take good care of your health.

I trust it will not be out of place if I say in closing, let your work, quite as much as your words, indicate that truth lies at the foundation of every undertaking.

NATURAL GAS, AND ITS EFFECTS ON THE CONSUMPTION OF COAL GAS.*

By E. B. PHILIPP, Findlay, O.

MR. PRESIDENT AND GENTLEMEN: At the second annual meeting of the Ohio Gas Light Association, held at Springfield, March, 1886, in a paper on "Natural Gas as a Competitor of Coal Gas," I gave the result of practical experience in the use of natural gas, in its crude state, as an illuminant. Much time had been spent in solving this problem, not only in regard to the practicability of its employment from a strictly photometrical standpoint, but also as to its use so far as health, convenience, and comfort were concerned. The various photometrical tests, given in detail in this paper, with the best and most approved kind of burners, showed its illuminating quality to be between 12 and 13 candles; but with this illuminating value seemingly against its use, and in competition with coal gas of from 16 to 18 candle power, nevertheless, on account of the remarkable cheapness at which it was furnished, it succeeded in successfully competing with coal gas; and, finally, to have superseded the latter entirely.

At this time effort had been made to increase the candle power by mechanical enriching, and also to purify it. These processes, however, were never continued, as the increased expense at that time would not warrant so doing. Since the time referred to in that paper, natural gas in its crude state has continued to be used in Findlay. On account of the great difference in its cost, and by using burners specially adapted to its consumption, it has, in the main, given general satisfaction. An experience of three years in its use in Findlay and in other places has shown conclusively that by using it in the proper way, and by obtaining it at a low price, it will successfully compete with any other illuminant. The question as to whether it can be used in its natural state, or without enriching, has been practically proved at Findlay. The gas celebration and public illumination at Findlay last June showed the extent and the satisfaction given by such use.

The fact of its practical use as an illuminant being undisputed, the problem and its solution as to how it can best be used will form the subject matter of this paper. As has been shown in the Findlay experience, satisfaction in the main has attended its general use; yet in Findlay, as in other towns, a desire for a better illuminant at a fair price has prevailed. This desire led to experiments, which have been successful, and which conclusively prove that natural gas enriched—or, in other words, its candle power increased and its detrimental qualities removed—will give complete satisfaction. Further, on account of the low price at which it can be furnished, it will, and has, undoubtedly become a successful competitor of coal gas.

In order to plainly understand and show this, the following chemical analysis of natural gas as found in the Western natural gas fields is given:

Ammonia (NH_3)	0·00
Sulph. hydrogen (SH_2)	0·88
Carbonic acid (CO_2)	0·88
Bisulphide carbon (CS_2)	0·00
Illuminants (C_2H_4)	0·50
Oxygen (O)	0·00
Carb. oxide (CO)	2·00
Marsh gas (CH_4)	95·74
Total	100·00
Specific gravity	0·57

The detrimental qualities of natural gas which tend to make its use in its crude state unsatisfactory are its heavy specific gravity and the excess of sulphureted hydrogen, carbonic acid, and carbonic oxide which it contains. Its heavy specific gravity makes the light flicker and unsteady, when subject to draughts or currents of air; and the excess of sulphureted hydrogen makes its use unpleasant, on account of the formation of sulphurous acid in burning. Now, in removing these detrimental qualities, and in increasing its candle power, it will successfully compete with any other illuminant, not only from a photometrical standpoint, but also on account of the low price at which it can be furnished. There are two practical methods of treating natural gas and of removing its detrimental qualities; one of which is by passing it through a complete coal process, from the retorts through scrubbers, washers, condensers, and purifiers, into the holder, and enriching it by using oil or naphtha in the retorts; while another method is to put it through a water gas process. The latter, on account of its being the cheapest and best, is to be preferred. This process is now being used in Fostoria, Fremont, and Tiffin, in this State, and in a number of cities and towns in the East, very successfully. In using the water gas process no change is made whatever in the construction of the apparatus. The only real difference in the process is that instead of using anthracite coal and steam to make water gas, natural gas is passed through the apparatus, and simply enriched and purified. The use of the cupola in the water gas process is to make, from anthracite coal and steam, carbonic oxide gas and free hydrogen, which together form water gas; and also to carburet or enrich the same by vaporized oil. The use of the cupola in the natural gas process is merely to carburet or enrich the crude natural gas by vaporized oil. By this process of carbureting its specific gravity is changed from 0·57 to 0·40, which makes it of about the same specific gravity as coal gas. The rest of the machinery belonging to the water gas process proper, consisting of the washer, scrubber, and purifiers, is also used in treating natural gas. The washer removes principally a black, clayey substance, very similar to lamp black, the scrubber removes the oily, condensable vapors; the purifiers remove the sulphureted hydrogen and carbonic acid. The result of this method of treating natural gas gives a merchantable, high candle power, non-condensable illuminant, free from sulphureted hydrogen and carbonic acid, with a specific gravity of 0·40, and with an illuminating power of from 22 to 24 candles, and which at a low price per thousand cubic feet completely and signally competes with and supersedes coal gas or any other illuminant.

A water gas plant, with cupola, washer, scrubbers, purifiers, and engine and blower, of a capacity of 75,000 cubic feet per 24 hours, costs (complete) between \$5,000 and \$6,000. This, used in connection with purifiers, holders, and mains of the coal plant, will make a complete plant for the purpose.

Now a few facts and figures in regard to natural gas treated in this way. The crude natural gas, unless the wells are owned or controlled by the parties interested themselves, is sold at various prices, depending upon how far the gas is piped. The price is usually so much per thousand cubic feet of gas sent into the holder. This can be metered through the station meter, or calculated by holder measurement. The price will average from 10 to 20 cents per thousand cubic feet. The material used, as in making water gas, is substantially the same. Anthracite coal is not used, for it is not needed. Coke is used in "blowing up the heat." Connellsville is the best, weighing 42 lb. to the bushel. Ordinary crude oil, the same as is obtained from the Findlay or Lima field, is used for enriching. The present price of coke delivered in this part of the country is \$4.50 per ton, and the present price of crude oil is about 1.35 cents per gallon.

In treating from 15,000 to 30,000 cubic feet of gas, three runs are usually made. In some places where the supply of natural gas is deficient, or in other words where the gas is not furnished fast enough, it takes, as a matter of course, longer to make the runs. Three runs, of 35 minutes each in the average case, treat from 15,000 to 17,000 cubic feet of gas. In other places where the supply is better, from 27,000 to 30,000 cubic feet of gas can be treated in about two hours. The average amount of oil used per thousand cubic feet is from 2¼ to 2½ gallons. The average amount of coke used is from 20 to 25 lb. per thousand cubic feet. A works whose output is from 15,000 to 30,000 cubic feet per day can send into the holder all the gas in less than three hours.

Now, without going farther into financial details, I will simply state that natural gas can be metered and sold at \$1 per thousand and realize a very satisfactory profit. The difference in the labor account between the old coal process and the natural gas process is fully one-half in favor of the latter; the difference in purification is about one-quarter in favor of the latter, and the wear and tear and renewal to plant is about one-fourth as much as in the coal process. In addition to the greater profit in furnishing carbureted natural gas, many other circumstances are greatly in its favor. There are no heated up, smoky retort houses; no stopped up stand-pipes; no naphthaline; no renewal of benches; everything clean and neat. The fact that gas of from 22 to 24 candle power can be furnished at a low price per thousand gives, in itself, very good general satisfaction to the consumer. The increase in consumption, which gas of this quality at a low price is sure to bring about, is a good thing; and above all, the satisfaction, in a general business sense, of furnishing a good light at a low price is, in itself, a great comfort to the gas manager. The cleanliness and comfort attending the process is certainly, also, a great object and benefit.

For these reasons then, in natural gas territory, where gas can be easily and cheaply obtained, and in territory where gas can be piped and furnished at a fair price, no city or town, no matter how large or small, can afford to ignore its use. Gas companies, where thus circumstanced, are most certainly standing in their own light in not changing their process, not only from a financial standpoint, but also from a good, general business standpoint; for the profit is certainly greater, the satisfaction in doing business with the consumer is much greater, and the satisfaction in the cleanliness and comfort of the process is certainly much greater. In case the supply of natural gas should fail, there is no loss on account of the investment in the plant, for the same plant can be used either for making water gas or a cheap fuel gas; so that no risk whatever is run on account of wasted or useless machinery. For these reasons natural gas has entered and will, wherever it can be obtained, most positively enter into competition with and take the place of coal gas; not only so, but it will also most effectually compete with and take the place of any other illuminant.

A few practical remarks on the longevity or life of gas wells, although in some degree foreign to the subject matter of this paper, may not be here amiss. The only durable supply of natural gas obtained in the Northwestern gas territory is found in the Trenton limestone. It is true that gas in considerable quantities is found in the shales above the Trenton; but this is not of continuance, being generally accumulated in pockets, which soon give out. The difference between a good gas well, or gusher, and a small well is due to the porosity or density of the Trenton limestone. I have here three samples of Trenton rock. This one, as you will observe, is very porous, of a spongy character, similar very much to a piece of pumice stone. This specimen came from the Karg well, at Findlay, the capacity of which is 12,600,000 cubic feet per twenty-four hours. The other specimen is also porous, but not so much as the piece from the Karg. This sample came from the Heck well, near Findlay, the capacity of which is between 5,000,000 and 6,000,000 cubic feet. The third specimen here shown is from a well in the eastern Findlay territory, which scarcely shows any sign of porosity, and, in fact, is very dense and close. The capacity of this well is about 500,000 cubic feet per day. These specimens show very accurately the comparative difference in the porosity and density of Trenton rock, on account of which the difference in the flow or production of the wells exactly to the same degree is attributed. There are many theories in regard to the manner in which natural gas is made or produced by nature. The two leading theories, and those which have the greatest number of advocates among experts, are that it is made or produced in the Trenton rock, or that it is made far below the Trenton. At best it is all theory and not a proved fact. It is, however, our theory that it is not made in the Trenton limestone, for the immense quantities of gas that have already been used or wasted could not actually have been made in the Trenton, as the rock area could not produce it. The Trenton rock, in our opinion, is but an enormous passageway or pipe line, so to speak, for the distribution or conveyance of the enormous volumes of gas which the drill has liberated by tapping this passageway or pipe line. Presuming it is true that the gas is generated far below the Trenton, it can easily be supposed, for it is all imagination, that with the enormous pressure at which it is packed or compressed in the place of manufacture, it would, on this account, find its way through the various strata until it reached the Trenton, and here becomes distributed. The shales and slates above the Trenton act almost completely as a barrier or stoppage to its rising farther; and when in some cases it does reach the shales above, this fact is attributed to the presumption that it reaches these pockets or cavities through fissures or breaks. For this reason, as the shales are very close and compact, the supply found in these pockets is not lasting. Now, as far as the life of a gas well is concerned, we can only theorize. All that we are able to learn concerning this important phase of the natural gas problem is from actual experience and knowledge, and from that limited knowledge form our conclusion. We know the flow of gas wells does diminish—not to such an alarming extent, however, as to discourage the investment of many millions of dollars in the business; for the natural gas territory of this country is of such enormous area that, should the life of the first wells drilled be comparatively short, others may be drilled in other parts of the territory, and (comparatively) the same amount of gas can be obtained. This has been demonstrated to be a fact as far as our present experience teaches us, and for this reason, if the average life of the wells should be of from five to ten years, as has been claimed, the supply can be kept up by farther use of the drill in adjacent territory not yet depleted. These facts and experiences from which we derive our conclusions are so numerous, and the ground to be covered in the consideration of this great problem so vast, that we can in this paper only mention, in a comparatively limited and concise way, some of the principal points or arguments in the matter.

* A paper lately read before the Ohio Gas Light Association.—*Amer. Gas Light Journal.*

ANCIENT MATERIALS FOR PAPER MAKING.

IT has been generally believed that linen rags have been used in the manufacture of paper only since the fourteenth century, and that previously to that the writing materials of the East were chiefly made from unmanufactured materials. This view must be considerably modified in consequence of a careful microscopical examination, made by Dr. Julius Wiesner, of the paper from El Faijum preserved in the Austrian Museum at Vienna in the collection known as "Papyrus Erzherzog Rainer." Many of these papers extend to the ninth, and some are even as old as the eighth century. The papers are all "clayed" like modern papers.

Dr. Wiesner's examination gave the unexpected result that these papers were all manufactured from rags. The fiber is mainly linen, among which are traces of cotton, hemp, and of some animal fiber; well preserved yarn threads are of very frequent occurrence. The manufacture of paper out of rags is not, therefore, as has hitherto been supposed, either a German or an Italian invention, but is an Eastern one. In addition to the Faijum papers, he examined also more than five hundred Oriental and Eastern specimens from the ninth to the fifteenth century, not a single one of which was a raw cotton paper; all were manufactured from rags, the chief ingredient being linen.

The examination of the substance used for "claying" gave equally unexpected results. In all the Faijum papers this was found to be starch paste, a substance which had been supposed not to have been used for this purpose before the present century; animal substances do not appear to have been employed for "claying" before the fourteenth or fifteenth century. In some instances well preserved starch grains were mingled with the paste; these agreed, in the form and size of the grains, with wheat starch, and were evidently prepared starch separated from the meal. In two papers, belonging to the tenth and eleventh centuries, buckwheat starch was found, and the cultivation of this substance must, therefore, be dated back to the tenth century. The object of the "claying" was apparently to increase the whiteness of the paper.

[Continued from SUPPLEMENT, No. 647, p. 10341.]

ELEMENTS OF ARCHITECTURAL DESIGN.*

By H. H. STATHAM.

LECTURE IV.

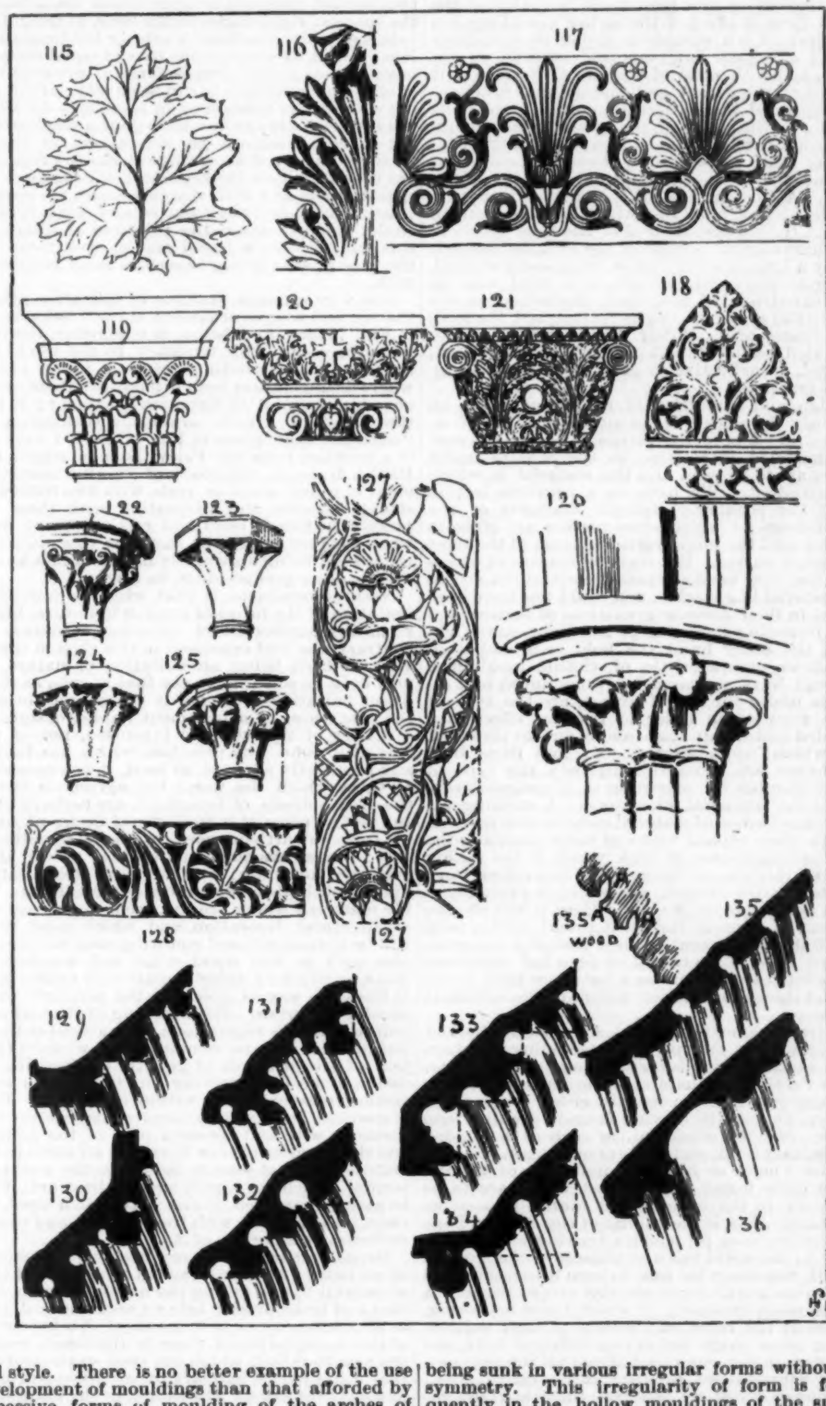
THE decorative treatment of architecture may be considered under two heads, that which is included under the definition of *mouldings*, or modifications of the surface in order to give variety of light and shade, and that which comes under the head of carved ornament. Mouldings are not, it is true, in general classed as "decorative" work, but they are so classed here, inasmuch as they form an important branch of the treatment of details in architecture, the subject which has been reserved for special consideration in this lecture, in distinction from the broad principle of treatment of the whole building in reference to its general plan and construction.

A moulding may be defined as a modeling of the surface of building material, in a continuous and parallel direction, in order to produce from it lines of contrasting lights and shadows which aid in giving force and expression to the main lines of the structure. If we suppose an opening, such as a square-headed window opening, formed simply of three stones squared on section, two set upright and the third set across them, the outer edges of these stones will present to the eye a sharp, thin edge formed by the meeting lines of the two surfaces of the stone, that which is at right angles to the wall plane, and that which is on the wall plane, and which two surfaces are always necessarily under different conditions of lighting, one in fuller light than the other, the meeting of the two differently lighted planes of surface alone producing the effect of a line, which, but for the varied intensity of light on the two surfaces, would be barely discernible. Under some circumstances this simple edge is all that is required in that position. If it be desired, however, to give greater force and prominence to this defining edge of the window jamb,† this can be accomplished by working this otherwise fine edge into the shape, for instance, of a quarter-round roll, sinking this roll a little below the surface of each face of the stone so as to leave, at each extremity of the roll, a little strip at right angles to the inner face of the stone. This strip, which is called a *fillet*, is a feature which occurs in mouldings of all schools, and serves, where necessary, as a defining boundary between one moulding and another, or as marking and emphasizing the break between the moulding and the main surface of the stone. If, for instance, we merely rounded the edge of the stone, and let our quarter roll die into the surface each way, we should hardly have anything which could be truly called a moulding; we should not see where it began and ended; we should merely have blunted the sharp edge of the angle. But with the quarter roll and the little strip at right angles to the roll at each extremity of it, we have now, in place of the thin edge of the original jamb, several distinct lines round the edge of the window, marking it and calling attention to it much more prominently than before. The two thin strips or fillets each make their own sharply defined line of light or shadow, according to the direction in which the light strikes them, and between them the roll moulding produces a more varied and broad gradation of light, a high light on the more prominent portion of its surface, shadowing off into half lights as the surface recedes from the light. All mouldings are composed of these two classes: surfaces which produce graduated lights and surfaces which produce sharp and defined lines of light or shadow, as the case may be. The method just described, of sinking the roll and leaving a fillet at each side of it, is the method characteristic of classic architecture, but not unfrequently used in early Gothic also; another method, quite different in effect and especially characteristic of Gothic architecture, is shown in Fig. 129, where it will be seen the roll at the edge of each projection is worked from the main surface of the stone, and its inner limits are defined by the stone being cut away so as to continue the roll moulding further round, and make a three-quarter instead of a quarter roll. This is a method particularly suited to a climate where there is a comparatively dull light; it produces a dark shadow behind the roll and throws it up strongly; under a very strong sunlight it would be rather too marked, or at least it would be unnecessary for the production of the desired effect. In both these cases, however, it is to be noted, and it is rather a curious point in regard to the effect of mouldings, that we are actually giving a greater appearance of force and solidity to the structure by *cutting away* some of the stone; the lines of light and shadow produced by modeling the edge being of more architectural value, up to a certain point, than the actual original bulk of stone, just as we saw (in Lecture I.) that greater constructive expression was given to a square column or post by removing some of its substance in order to mould it into an expressive architectural feature.

It is not always the case that the use of mouldings thus adds force to the portion in which they are worked; this depends a good deal on the situation and the manner of designing the buildings. In some cases they may be used rather to give lightness to what would otherwise appear too heavy a mass, as we saw in the case of the division of the Greek architrave (Fig. 53 *ante*) into three horizontal faces by fillets, which are in themselves a simple form of moulding. In general, however, mouldings add force to the portion of the building on which they are worked, and their especial function is to emphasize by lines of light and shadow the main lines or divisions of a building. Thus, when a building is divided up into horizontal stages, these are marked usually by bands of stone (or brick, if it is a brick building) moulded in the direction of their length, and which, as previously observed, are called in building language *string courses;* and the moulded cornice, which forms the crowning feature of the wall, is only a final string course, deeper and more highly elaborated, so as to dominate all the others and assert its place as the crowning member. The designing of the mouldings of the various string courses in a building is a very important and delicate matter, demanding much more care and attention than it sometimes receives. The same profiles and members should not be repeated in different situations, which would produce an effect of monotony: besides which various situations require various treatment—a thin and light succession of lines in one place, a deep shadow and a broad light in another; and those who are really careful with mouldings, after drawing them in full size, will have their lines reduced exactly by scale on to a rather large scale "detail elevation," to judge the better of their effect in relation to the whole. In designing the full size profiles of mouldings, it is necessary to bear in mind that the only situation at which their profiles when executed become visible to the eye is at the external angles of the building, and that they meet there at an angle of 45°, and consequently, when viewed across the corner obliquely (which in most positions of the spectator they will be), their projection becomes exaggerated, and a moulding which appears right on paper will thus appear to have too much projection for its height when seen in execution.

Apart from the use of mouldings as marking horizontal divisions of the building, they are also used largely in giving effect and expression to arches over doors or windows, or to those of the arcades which form an important portion of the construction of a building in an arcuated style. There is no better example of the use and development of mouldings than that afforded by the successive forms of moulding of the arches of mediæval buildings, in England especially, where the mouldings are perhaps finer and more effective than in the Gothic architecture of any other country. A few examples of the typical varieties of English Gothic mouldings in successive periods of the style are shown in Figs. 129 to 136; and these serve to illustrate also the manner in which the moulding, under all its changes of detail, preserves nearly to the last the idea of its origin, as the moulding of the edges of a successive series of arch stones. In the first example, Fig. 129, which is a moulding of late Norman or transitional date, the original form of that arch, as composed of three arches of square section one beneath another, is as obvious as possible; the roll moulding is simply worked out of the square edge of each arch, and the outline of the primitive or essential constructive form of the arch is hardly affected by it. In No. 130, which is a later example, coming pretty nearly into the period of Gothic proper, the square form is still equally discernible, though the mouldings have become more elaborated; the chief difference lying in the fact of the original round moulding being now worked with a fillet on the face and one at each side, and the interposition of a small but deeply cut hollow on either side of it, which makes a strong black shadow; the shadow being all the more effective by contrast with the lines of the fillets between it and the roll member. If the roll had merely been carried round without a break into the hollow moulding, the whole would not have been nearly so light and effective. This, which is a common form of moulding in early Gothic work, is one of the most effective in existence, though composed in a very simple manner. The deep hollow which here appears is one of the most marked characteristics of Gothic mouldings. In Fig. 131, which is a moulding of the fully developed "Early English" period, it will be seen that the hollows are more numerous, the mouldings of this period often presenting a very large series of these small deeply cut hollows, with sharp lines of light formed by the projecting portion between them. Here again it will be seen that, though the moulding has become more complicated and much less symmetrical in its parts, it still rigidly follows the original square line of the arch members. A peculiar feature of the mouldings of this period is that the true circular form in the working of the hollows is almost entirely abandoned, the hollows being sunk in various irregular forms without heed to symmetry. This irregularity of form is found frequently in the hollow mouldings of the subsequent Gothic periods, though not so generally as in the early English period; and as the main object of the hollow is to produce a dark shadow, and the shape of it cannot possibly be accurately seen by the eye when the moulding is *in situ*, there seems reason in avoiding any special trouble in making the hollow a perfect circle: though it is possible that the eyes of the mediæval builders did detect a certain difference of effect, or at all events fancied one, in these irregularly worked hollows, and worked them in that way with a definite purpose. In Fig. 132, which is a moulding of the date of the "decorated" period, we see that the square form has been departed from in the upper member of the arch—it is shown by the dotted line; but the arrangement of the moulding is as if we had beveled off the edge to an oblique face first, and then worked the moulding on the face of that.

The rest of the moulding is still, however, arranged on the square form, and it shows the rather large hollows which became prevalent at this period, and also the return to the circular form of hollow moulding. The upper moulding on the bevel, consisting of two reversed curves of wavy contour, is a very



* Delivered before the Society of Arts, London, December 19, 1887. From the *Journal* of the Society.

† In building phraseology, "jamb" is the *side* of any opening in a wall, or that portion of the thickness of the wall that becomes visible when the opening is cut through.

common one in middle and later Gothic architecture (see examples 134 and 153), and is a very effective moulding when there are sufficient deep hollows to contrast with it and throw it up, as it affords a great deal of delicate gradation of light and shade. Fig. 133 shows a "late decorated" moulding which is much more irregular and wild in outline than any of the previous examples, and on first looking at it we might think that the square form from which they are still, be it remembered, actually worked in the stone—all these mouldings, whatever outline they take when complete, are worked out of so many squared stones—had been ignored; but on ruling out the squares in dotted lines, we find that the fillets on each group of mouldings come up to the line and represent a portion of the original surface of the squared stone. As we come later in time, however, there is an obvious tendency toward cutting away the stone to the oblique line, as shown in Fig. 134, in which the projecting member at the left is only the "hood mould" or "drip stone" which projects over the arch beyond the line of the wall to throw off the rain (as its second name implies); the whole of the rest of the moulding is on the bevel. As we come to the latest period of Gothic, this tendency becomes greater. Fig. 135 is an example of a late Gothic moulding, and here it will be seen that the variety and force of effect of the earlier mouldings is a good deal lost; it is a succession of similar mouldings and hollows at regular intervals and entirely on the same plane, and with none of the effective in-and-out arrangement of the earlier arch mouldings, which so precisely expressed the construction of the arch, stone under stone; on the contrary, the construction, though in a large Gothic arch of that section it would still consist of two or more series of arch stones, is nearly lost sight of, and the moulding looks as if cut out of one large stone. A further descent into ineffectiveness is shown in the kind of moulding which became common in the latest Gothic period, that of the type shown in Fig. 136, where a great portion of the moulded space is occupied by a large shallow hollow, very easily worked, and proportionately ineffective; it is what may be called a "save-trouble" moulding, the indication of a period when the style was degenerating, and the force and effectiveness of its earlier details giving way to easily executed, scamped, and ineffective work; which, be it noticed, is ineffective in great measure from ignoring construction.

The design and character of mouldings is, in all spontaneously developed styles of architecture—*i. e.*, in all styles previous to the classic Renaissance—considerably modified in relation to the climate under which they are to be seen and the material in which they are executed. We have in a previous lecture glanced at the peculiarly delicate character of the Greek mouldings (of which some profiles are given in Fig. 76 *ante*), and the employment in them of the most refined order of curves. But such refinement of execution could not have been adequately carried out except in a fine material like marble, and could not have been appreciated in their delicate gradations of surface and fine sharp bounding lines except in a light, sunny climate. On the other hand, the bold rolls and deep round hollows characteristic of Gothic mouldings, which would have appeared too pronounced and almost coarse under the sun of Greece, are the type of mouldings required in order to produce effect in a more clouded and damp atmosphere, and to throw off the rain which pours upon them; and these bold rounded forms are, moreover, precisely the type of forms most suitable for execution in a comparatively coarse, granular material like stone. A striking example of the influence of material may be seen on comparing with these typical forms of stone moulding the wooden moulding shown at 135A, which is the raking mould of the canopies of the splendid oak screen work in Lancaster Parish Church, and which is probably of about the same date as No. 134. Here it will be seen that instead of digging the usual round cavity, as in 134, so suitable for execution in a granular material, the shadow is got by a cavity as deep but shallower and of a pointed section, being a far easier form to cut out of wood than the rounded hollow of the mediæval stone mason.

Decorative ornament properly so called is distinct from mouldings in this, that while moulding is a shaping of the surface which is carried along continuously, decorative carving is a shaping of the surface which is varied transversely as it proceeds, either regularly or irregularly. Decorative carving is again divisible into two classes, *abstract* ornament, or such as is founded only on abstract form, and *natural* ornament, which is founded on a more or less close imitation of nature. There are early forms of ornament which are to be traced purely to the imitation of obsolete constructional details. The stone railing of the Sanchi Tope in India, for instance [of which a drawing was shown], is nothing in the world but a reminiscence of a wooden railing with broad-headed pins to keep it together, and with these pins surviving as circular carved bosses. A curious Egyptian ornament, of which I give a drawing, is produced by the repeated forms of painted earthen jars, of the same shape but in two different tints, and painted overlapping, one vase hiding half the next one, etc. This arrangement produces a decorative effect, but it is one in which we feel that there is a false element; the form of the jar contributes nothing to the decorative effect; and any other form of good lines would have done as well; it is the effect of repetition and alternation alone that was aimed at, and hence the jar form is a mere impertinence; abstract forms are all we require. It is the special character of ornament of this class that it *means* nothing; it simply deals with abstract form. There are two main kinds of abstract ornament—geometrical, which covers a space, and alternating, which is arranged in a succession in one or more directions. As examples of geometrical ornament may be taken the well known square pattern called the Greek fret, or sometimes the "key pattern," a form of ornament which existed in one form or another all over the world at various times, and which, in its best form as designed and used by the Greeks, has held its own for two thousand years and more, and now seems as little likely to go out of favor as ever.* It is an ornament that seems to combine in itself all the requisites or attributes of a geometrical ornament for general application; it may be used either in a very simple form, or it is capable of a considerable amount of complexity; it is not difficult to execute; its square, precise forms are essentially architectural, and seem as if they belonged naturally to building, and it fills up very evenly and fully the space in which it is introduced. Of the same order are the apparently much more complex forms of Saracenic interlacing ornament, which on analysis will be found not so complex as they appear at first sight; the multiplicity of parts in many of them is puzzling to the eye, but the key to them is very soon mastered. Both these and the Greek fret illustrate one of the requirements to give interest to ornament of this class, viz.: that it should present to a certain extent a problem to the eye; it should give evidence of thought and contrivance. It is perhaps on this account that these forms continue to give pleasure and to be accepted, while such an ornament as the guilloche (Fig. 78 *ante*) is felt to be commonplace and threadbare, because its construction is so manifestly simple, and the eye takes it all in at once. The other forms of abstract ornament are those, as observed, which consist in the arrangement of repeating or contrasting forms for the sake of repetition or contrast of form. For in most ornament, and in abstract ornament more especially, repetition at equal distances is an essential element. If we draw two parallel lines and arrange broad black bars across the space at right angles to the lines, at irregular intervals, we produce nothing whatever but irregular markings; but if we arrange our bars at equal distances, we have at once a very simple form of ornament. If we modify each alternate bar in some way, either by making it shorter or thinner or in some way differing from the intermediate one, we have gone a step farther, and got a dual element—an alternation of contrasting forms. Similarly, if we arrange circles in a regularly spaced order, we have the beginning of ornament; if, after spacing them at a little distance apart, we insert a contrasting and narrower form of any kind between the circles, we have again the principle of alternation, in this case between a broad and narrow form, which is the type of alternating ornament most frequently met with.

* It is at present the favorite and most common ornament for the bordering of the lining of first-class railway carriages.

One very common example of this alternating type, the egg and tongue ornament of the Greeks, was shown in Fig. 72 *ante*, and below it is another, the bead and real ornament. This tendency to the use of two contrasted and alternating forms is found everywhere where ornament has been attempted; there are numerous examples of it in Egyptian ornament; it is seen in the beautiful Greek ornament (belonging to the "natural" type) given in Fig. 117; and I have a sketch of a necklace from the Pelew Islands, which is in the British Museum, composed of an alternating arrangement of round seeds or pods with two little flat shells strung between and alternating with them, which is exactly the Greek bead and reel ornament in a somewhat rougher form; the taste for this alternating arrangement being apparently innate in mankind; at all events, quite prehistoric in its origin.

Natural ornament is that which is founded on the imitation of the forms of growth in nature, but this by no means implies direct imitation of nature; on the contrary, the best ornament of this class in the world is very far from being an imitation of nature, and we may even go so far as to say that as soon as it becomes direct imitation of nature it ceases to be ornament in the true sense. For ornament implies *design*, which is a matter of thought and invention, not of copying. The reasons for this principle, which has been tacitly and intuitively adopted, at least, if not consciously, in all those which the world has agreed to recognize as the best schools of ornament, are perhaps threefold. In the first place, it is the natural desire of man, when he turns to artistic work, to create something of his own; but we are not made so that we can absolutely originate anything; we take hints from nature, and upon their basis make our own subcreations. Then, in the materials which are available for the execution of architectural decoration, and which must be such as will be permanent and enduring, and for exterior work also such as will stand wind and weather, nothing like a satisfactory direct imitation of nature is possible in the same way as it is with the painter's more manageable materials. Stone carving at the best can never imitate nature's vegetation; if it attempts that, it can but produce a coarse reminiscence; whereas the imitation of the principle of growth, the devising of a new design of our own carrying out in our own way a suggestion from nature, is within our power. Thirdly, it is essential that architectural ornament should be in harmony with and appear a part of the architecture; and the forms of nature, if used in an attempt at direct imitation, do not seem to belong to the world of architecture, which is a highly artificialized art; they must be architecturalized, if one may coin a word, to bring them into harmony with the building, and render them æsthetically a portion of it.

Hence it arises that in architectural ornament founded on nature we take refuge in conventional treatment of natural forms, taking the natural form as a basis or idea and transforming into an architectural decoration in an arbitrarily chosen manner. No better example of this could be found than in the Greek treatment of the acanthus leaf, which has been so successful indeed that it has placed its mark on architectural foliage ornament ever since. The sketch of the natural leaf and the conventionalized one side by side (115, 116) show better than any mere words what is meant by conventional treatment of nature in ornament. The leaf is a serrated one with deep indentations, but not regular in form.

The Greek takes the fact of serration and indentation, but reduces these to an architectural symmetry. The natural leaf is thin; the Greek makes no attempt to give any corresponding appearance of tenuity to his leaf—it is a marble leaf form constituting a portion of architectural decoration—an architectural leaf; it has no occasion to simulate (which it could not in any case successfully do) the frail character of the real leaf. The leaf has a central rib with minor ribs or ridges radiating from it; this is an essential constituent of the design of the leaf, just as much as the indentations, and it is duly preserved in the architectural leaf, but in a symmetrical and conventionalized manner. The same principle is seen in the ornament from the Erechtheion, shown in Fig. 117. Here we have the system of the growth of petals from a central stem, but more highly systematized so as to harmonize it with the architecture; the forms used are said to be, and may be, derived from the honeysuckle, but they are not allowed to retain any direct resemblance to the flower. Fig. 118, which is a piece of Gothic foliage from Wells Cathedral (on a much larger scale than the Erechtheion ornament), is interesting for comparison as exhibiting in a different style of work exactly the same idea of a conventional growth founded on natural growth; the leaf showing some of the main characteristics of a leaf, but thickened and solidified into a fitness for architectural service; the growth from a central stem again is retained as the idea, but treated with architectural symmetry. The one ornament is in marble, the other in stone; they are the work of men as remote from each other in time and place as in social and mental habits of life; but they are both first-rate examples of ornament, and different as they are, they both illustrate the same idea of the relation of decorative forms to natural suggestions.

The acanthus leaf forms, as has already been seen, the principal decorative detail of the classic capital, and its influence may be traced throughout many variations on this form of capital which have been made in Byzantine, Romanesque, and early Gothic work, the latter especially in France; as well as in further variations made in the time of the Renaissance. It is perhaps difficult to say why the capital of the column should have been selected especially as a position for the employment of decorative foliage in the first instance. Probably at the time the Corinthian capital was developed it was found that ornamental leafage afforded a convenient means of masking the awkwardness of the transition from the round shaft to the square abacus, and these forms having been used in that position with such admirable effect by the Greeks, and by the Romans working under Greek influence, became accepted as the happiest method of treating that portion of the design, succeeding generations having tacitly confessed their inability to improve upon it; for the quasi-classic capitals of the early Gothic period, though variations from, can hardly be considered as improvements on the classic capital, and the finest and most characteristic Gothic capitals depart from it so completely that they may be said to belong to another type. The foliage forms have, however, this special suitability for the capital, that they convey naturally an idea of upward springing and spreading of the line of the column which is very suitable at the capital; otherwise, there seems no special reason why foliage forms should not also have been employed at the transition from the base to the shaft, as well as from the shaft to the capital. In Byzantine and Roman work they are, in fact, partially so employed, in order to cover and fill in the angle spaces of a square base on which the circular base mould of the column is set. In regard to the classic capital, there has been a want of enterprise and originality shown in its modern treatment; it has been accepted and copied almost slavishly, an ancient example being simply imitated over and over again; whereas it might certainly have been possible to have evolved some new treatment of it; to retain its highly conventionalized and architectural style, but to conventionalize some other leaf than the acanthus, and there is still, I think, something new to be done with it in that way, if people would take the trouble to fairly try, instead of adopting the easier method of copying. Nor need it be a rigid rule that all capitals in a building of classic manner should be precise repetitions of each other. It would be possible to give new interest to the detail of a columnar building by treating the capital with similar general outline and form and with differences of detail, an effect of which Gothic buildings afford numberless examples, but which, as far as I know, was yet to be tried in modern classic work. Of course the classic type of capital is too severely designed a form to bear the amount of variation which we see in Gothic capitals (even in the same building), but it may bear a certain amount of modification without losing its main characteristics, and would gain in interest thereby.

During the transition from classicism to mediævalism, however, we meet with a good many examples which have the appearance of experimenting with the capital, though some of these may be considered rather as corruptions of than improvements on the original form. In the Byzantine example, Fig. 119, we have the general form of the classic capital with the acanthus leaf left uncut on the edges, which can hardly be called an improvement, and seems more due to a desire to save trouble than anything else. On the abacus of this capital is placed a block with a fillet and a beveled under side, which looks like a renewal of the Roman fallacy of placing a slice of the architrave on the top of the capital, but the Byzantine architects have left out (to their credit) the now useless architrave, frieze, and most of the cornice, leaving only what looks like a clumsy form of the crown moulding of the latter. Fig. 120 shows another curious but very illogical experiment, in which a kind of reminiscence of the Corinthian capital is placed over a nearly orthodox Ionic capital. Fig. 121 is another very characteristic Byzantine form, in which the bell of the capital is convex instead of concave,* and the abacus and necking are treated with floral ornament of their own. The decoration of the necking in this way seems a mistake, it weakens the feature and does not separate it sufficiently from the foliage of the capital. The peculiar form of angle scroll of this capital should be noticed. This is one of the thousand variations played upon the scroll or volute which first became a recognized feature in the Corinthian capital, and which was introduced to give support to the angle of the abacus. This angle scroll has been one of the playthings of architecture ever since. For a considerable period in early Gothic architecture it was reversed and turned inward toward the body of the capital, as shown in the early Gothic capital, Fig. 122. There are Italian Renaissance examples showing a similar treatment in a more classic form of capital. This is what happens when one feature is invented, in a fortunate moment, which is seen to be a really good and useful one; it lays hold of architecture, and refuses to let go its hold however it is twisted about and disfigured. The early Gothic architects in France used it for a long time on the angles of their capitals, in variously modified forms, long after the resemblance to the foliage of the classic capital had disappeared. Then a leaf was rolled round under the angle of the French capital to take the place

* This convex Byzantine capital became the parent of a whole tribe of capitals in early French Gothic and thence in Norman and English work.

of the volute, and from this angle leaf, solid and heavy in substance, grew the characteristic form of foliage of the early English Gothic capital, as shown in Fig. 126, a typical example from a Lincolnshire church, but which probably had its first origin in France. That is a form so different from the classic capital that the historical relation between them would hardly be suspected if we had not such a large train of intermediate examples in existence to illustrate it; and, what is more important to our main argument, the relation of the design to natural forms is very nearly the same as in Greek ornament. It is true that the capital, in its general design, partakes of the irregularity of nature, and makes no attempt at the symmetrical arrangement of Greek ornament; but otherwise it is no more an imitation of nature than the Corinthian capital, its forms being conventionalized suggestions or reminiscences of natural growths, only in a form specially suited for execution in stone, just as the finer Greek forms in Fig. 117 are specially suited for execution in marble.

The phase of experiment through which this development of the Gothic capital from the classical passed is curiously illustrated in the four small capitals figured 112-3-4-5, which are all close to each other in a wall arcade just inside the west door of Peterborough Cathedral. These must all have been worked at the same time, and they look like the deliberate trying of experiments with different forms of capital. Fig. 125 is nearly the type of capital shown in Fig. 126, except that the lines of the leaf stems are straighter and more abrupt; they have not acquired the life-like curves of the rather later example (126), in which the leaf forms seem as if the bell of the capital, like Aaron's rod, had budded from an inherent impulse. Later in the Gothic style the foliage lost this appearance of springing inevitably out of the bell of the capital, and assumed the aspect of being bound round it independently, with much inferior architectural effect.

Next to the capital with its acanthus or other leaf, perhaps the most important element in natural ornament has been the scroll. The scroll indeed is not itself a natural but an abstract form; but the arrangement of natural ornament on the scroll line enables us to carry it on with an appearance of growth and freedom, and with an effective contrast to the horizontal lines of the building. The first and most essential quality in a scroll design is that its curves should be cleanly drawn and designed and they should all be tangents to the straight portions from which they spring. No amount of richness and effectiveness in leafage detail will atone for any initial defect in the curvature of the lines, and this is why the Roman scroll ornament, rich and broad in detail as it often is, nearly always looks common and awkward in comparison with Greek scroll design. In Roman work the scroll is not sufficiently conventionalized and geometrized, it is left to assume something of the accidental breaking and irregularity of line which a real branch might assume if bent into a scroll form; and this fatal error destroys all its beauty, and reduces it to a kind of cabbage garden ornament. In Greek work the scroll is drawn with geometrical precision and in clean, sharp lines, as shown on the lower part of Fig. 117, for instance; and in any cases where leafage forms a more important portion of the scroll than this, the precision of the curve and the clear character of the lines is never lost. The same tendency to severe line may be seen in the Indian example (Fig. 128), which, like a good deal of work found in India, shows manifest traces of Greek influence. In the best period of Gothic work (as in Fig. 118) the clean character of the curve is also preserved, as well as in the best Italian Renaissance ornament. When we come to late English Renaissance, we find, as in Roman work, broken and crippled curves, and straggling and ragged festoons of flowers, doing duty as "ornament;" and in the later French Renaissance of Louis XIV. date, so far has the true idea of scroll design been lost sight of, that we find one of the main features of Louis Quatorze and Louis Quinze ornament consists in the introduction of a number of short portions of scrolls which only touch either on the convex of their curves, and which have lost all appearance of unity or continuity of design, and form merely a bundle of patchwork unworthy of the name of ornament. Architecture at her best will have nothing to say to these crippled and ungeometrical curves; they are not ornament, but only bungling. A curious example of the defect of this bad drawing of the curve is shown in an example of Indian ornament in low relief (Fig. 127), from a square pillar in the Indian Museum at South Kensington. This is an odd mixture of conventionalism and naturalism. The separate flowers are conventional, and very well treated, the lines of the stems are only partially conventional, and are laid out in badly designed curves, neither natural nor geometrical, but with a kind of pretense of being either or both. Hence what might have been a good piece of ornament has been spoiled. Curves are exacting things, they demand respectful treatment, and if laid out at all as a portion of ornamental design, of which they form a most effective element, they must be laid out truly and geometrically, and if neglected in this respect they will amply revenge themselves on the designer.

But architectural ornament has to be considered not only in itself, but in relation to the building. When we regard ornament in this relative sense, we shall see that it may be considered under two heads, *surface* ornament and *functional* ornament; the former being that which is employed merely to cover a surface which would otherwise be a bare space, and give it more interest; the latter being employed to give an emphasis to some portion of the building which has a special function in the design. Thus the capital is functional ornament, so is the fluting of the columns, the moulding of the bases, or the ornament frequently introduced into one or two of the arch mouldings in Gothic architecture. We find this use of ornament illustrated equally well in other objects besides architectural ones; for instance, we may take as an example an Egyptian bottle, which is seen in one of the wall paintings in the British Museum, in which the body is a terra-cotta brown with a thin green spiral line round it, and the neck is white with black rings. Here there is functional ornament distinguishing the neck of the bottle from the body; a very early example of a method of using ornament to give special expression, which has been used in a thousand different ways since. Surface ornament may be and often is derived from the arrangement of constructional materials; for instance, there are some drawings here of Saracenic ornament, one of which is derived simply from the interlocking arrangement of bricks of a certain shape and of three different colors; another is formed by the arrangement of tiles, which must be arranged on some system, and may as well be arranged in a decorative manner. Then again surface ornament may be derived also from geometrical or from natural forms, arranged so as to form a continuous device or *diaper* over a surface, without in any way affecting the architectural expression or design, but merely giving something to take the eye and to break up the surface, where otherwise it would be a blank. For this use of ornament simple forms which are effective by repetition are the best; it is not worth while to expend forms of higher elaboration merely on the filling up of blank spaces, unless the spaces are such as to furnish an opportunity for painting in the intellectual sense, and that is another art, not a part of architecture, but a separate art to which architecture is the framework.

There is some relation to be observed between the nature of the ornament and that of the surface on which it is executed. For instance, in the functional ornament which often decorated the separate mouldings of the Greek cornice, there was generally some relation or resemblance between the leading lines of the ornament and the section of the surface on which it is executed. Thus a Greek ornament such as that at Fig. 117 would more generally have been executed on a delicately curved surface, convex below and concave above, somewhat resembling the lines of the narrower alternating member of that ornament. The egg and tongue ornament (Fig. 72 *ante*) is usually executed on a member with a convex curve turned downward, somewhat like the curve of the outer side of the "egg" member of the ornament. The Greek fret or key pattern again, to which we have referred, is never in any one instance that I know of executed except on a flat surface, with which alone it is in accord; on any curved surface its severe square lines would be out of keeping with the position, and would suffer a distortion which would interfere with the essential character of the ornament.

Another thing to be noted in regard to surface ornament is that it must never in any case be so designed as to conceal or contradict the nature of the surface on which it is placed. As an example of what is meant, a drawing of a Roman mosaic pavement design is exhibited, in which the pattern, a variety of the Greek fret, is made, by dint of shading and a perspective arrangement of the lines, to appear as if the bars composing the pattern were standing up on their edges, thus giving the floor, which is really a flat surface intended for walking on, the appearance of a kind of gridiron. This is a flagrant example of bad taste; but blunders of the same kind, though not often so bad as this, are not infrequent in wall and floor decorations.

In ornament derived from nature, whether functional or superficial, it is exceedingly important that consistency of style should be preserved, especially in regard to the degree of approach to nature which is admitted. In this latter respect a great deal of the ornament of the school of the Adams, which has come so much into fashion lately, is exceedingly faulty; it is not uncommon to find combinations in which there is a scroll, perhaps, of conventional acanthus leaves, with a spray of purely naturalistic foliage springing from it, a mingling of contrary *motifs* which is absolutely at variance with any idea of style at all. Still worse is the mingling of natural forms with artificial ones, of which there has been too much in Renaissance as well as in modern French work, and worst of all, perhaps, the fabrication of ornament by the imitation of artificial objects alone. This is, wherever and however it is done, the worst and most vulgar form of architectural ornament. There are degrees of badness in it, no doubt. It may consist of artificial objects rather effectively grouped into a kind of decorative bundle, as is the case in some French work and in some of the ornament of the school in which Grinling Gibbons was prominent; or it may be, as in a well known Roman frieze, a mere collocation of utensils carved without even the pretense of arranging them in a semi-decorative manner, which is about the lowest barbarism to which architectural ornament can descend.

(To be continued.)

SPECTRUM ANALYSIS.

By W. IVISON MACADAM.

IN the search after truth, chemistry has called to its aid nearly every other branch of physical science, and by means of the forces thus impressed into the service has been able to accomplish deeds which otherwise never could have been worked out.

In 1862 Professor Bunsen, of Heidelberg, intimated to the scientific world the results of his researches on spectrum analysis. Since then rapid progress has been made, and now in the five-and-twentieth year of its existence we find not a slender young man, but a veritable giant—a giant who, if he continues to grow—and he promises to do so—will soon overtop many of the other children of chemistry. Already spectrum analysis has overstepped the bounds of this world, and soaring aloft has enabled us to tell the composition of the sun, although that luminary is distant from us a computed ninety-one millions of miles. The more distant stars have also fallen a prey to this giant, and having fed upon worlds, his unsatiated appetite has caused him to swallow even those curious gaseous collections known as nebulæ. His empire thus extends from earth to sky, and whatever can be seen, whatever gives out light, that sprectrum analysis has broken up into its elements. By the aid of spectrum analysis it is fully more easy to tell the composition of the sun and stars than it is to give the analysis of a simple terrestrial salt.

As early as 1675 Newton communicated to the Royal Society of London the results of his experiments in the decomposition of light. His diagram I show you upon the wall. It is simply a representation of a ray of light passing through a round hole in a shutter and into a darkened room, where it is made to go through a prism and fall upon a screen. It is thus broken into its component colors—red, orange, yellow, green, blue and violet. Newton called this the "solar spectrum," and in order to manifest that white light was in reality a unity of these colored bands, he made this spectrum pass through another prism and reunite into a beam of white light. The electric spectrum can in a similar way be split up into colored bands, and these can again be reconstructed into white light. Another point to which Newton called attention was the fact that each of the colors of the spectrum was monochromatic; in other words, they could not be further split up.

Sir David Brewster advanced a theory that at least some of the colors of the spectrum were due to overlapping, such as the green, which was supposed to be produced by the yellow and the blue, but this has not proved to be correct. Helmholtz has conclusively demonstrated that each member of the spectrum is, so to speak, a primary and not a compound color. I show you diagrams of how he arrived at this result. Light is due to undulations of the elastic medium pervading space, and is similar to sound in this respect, or it can be compared to waves on the sea. The size of the waves and the rapidity of their motion determine their action upon the eye nerves, and cause the sensation of color to be sent to the brain, which receives the impression. While we may speak of light being like sound in its action, the power of the brain determining it is not nearly so delicate. A human being may hear eleven octaves, from the deepest bass of sixteen vibrations per second up to the highest note, which is caused by some 4,000 vibrations per second of time; but the same individual only can see, so to speak, less than one actually. Gentlemen, as a rule, are less able to distinguish between colors than ladies, or those who may be trained to determine between slightly different shades.

In the solar spectrum the red contains the greater portion of the heat rays, the yellow those of the light rays, and the blue the chemical rays. There is no actual difference in these rays except in the wave length and in the intensity of the vibrations. The blue ray is the great agent in photography.

Wollaston discovered, or called attention to, the black lines which are observed to be numerous in some parts of the solar spectrum. Fraunhofer also made a study of these lines and mapped them. There are hundreds of them, their relative positions remaining the same under the same conditions whether these be associated with sunlight, moonlight, or the light of planets and stars, etc. All show black lines, and this fact makes it evident that there is in each instance something acting outside and independent of our atmosphere. These lines are not simply the result of the passage of light through air, else they would be of different intensities, according to the distance of the planet or star from our earth and according to the relative position of the sun to the earth at various periods of the day.

Solid bodies, when subjected to heat, give out in succession red, yellow, and blue rays. A piece of iron when heated assumes first a dull red, changing into yellow, and latterly, under great heat, to blue. The same holds good with any other solid body.

I shall now heat a few metals in the electric lamp, and show you the various bands they throw upon the screen, and I wish you to understand that any particular band shown indicates that one particular element is present. Both the color and position of the band must be noted, and as a test it is unfailing. We may also show that every gas has its own spectrum, and you can easily perceive how great and useful are the discoveries made in connection with the spectrum. By its aid we can, for example, determine what elements we have in the sun, stars, nebulæ, etc., which it would be otherwise impossible to analyze. Provided we have light from a celestial body, distance, however vast, makes no difference to the accuracy of the results. Not only can we thus tell which of the already known elements are present, but by the spectrum we can discover bodies which were previously unknown. As a stimulus to any one who may desire to be a great discoverer, I may mention that there is a strange band in the spectrum of Jupiter which indicates some element we as yet are unacquainted with.

You will have noticed that temperature has nothing to do with these gaseous spectra; gases, therefore, differ from solids in this respect. So long as a gas is a gas or so long as the heat is sufficient to convert a solid into a gas, then the spectrum is permanent, and unchanged by any further addition of heat. Take sodium as an instance. This element can be compelled to give its characteristic yellow flame and band by means of the heat obtained by burning bisulphide of carbon (1,295° C.), burning sulphur (1,820° C.), coal gas flame (2,350° C.), carbon in oxide flame (3,042° C.), hydrogen flame (3,259° C.), oxygen hydrogen blowpipe flame (8,061° C.), or the heat of the electric arc. At all these various temperatures the color given by sodium is yellow, and the band in the spectrum is at the fifty line, from which point it never varies.

I have shown you that different gases and substances burn into different colored flames, and that by close observation of the color you may determine what is being consumed. I take a thin piece of wire and show you the color of the sodium flame. This substance is very abundant in nature, and we need go no further than ourselves to at once obtain a supply of it. I put this wire in the flame of this Bunsen burner. After drawing it between my finger and thumb you see that a distinctly yellow flame results. That is the yellow of sodium, which is in my body. You observe it burns a short time only, but I can renew it by again drawing my finger over the wire, or again if I wet it with my tongue, or a little dust from the floor will give the same flame.

To give you an idea of the extreme delicacy of these results, I may state that Professor Bunsen, while working on the chemical composition of the Durkheim mineral water, found, by means of the spectroscope, some bands which could not be referred to any element then known. These bands were chiefly two bright blue bands accompanied by some red bands and two violet bands with two very bright red bands. These lines were afterward shown to belong to two new elements called cæsium and rubidium, but before sufficient material could be obtained to test these bodies in the ordinary wet way, 40 tons of water had to be evaporated, the resulting salts of which yielded some 200 grains of the mixed chlorides of these new elements. Now, 40 tons of water are equal to 8,960 gallons—53,760 ordinary black bottles, or 4,480 dozen of quart bottles. From these figures you can see how extremely delicate these spectroscopic reactions must be.

I now show you the colors obtained from some substances which are gaseous at ordinary temperatures by passing the electric spark through glass tubes filled with them. A great improvement in this class of observa-

tion is due to Professor C. Piazzi Smyth. The older method of observing these phenomena was by taking the observation across the section of the light through the side of the tube. Professor Smyth conceived the idea of turning down the ends where the wires were attached, and so getting the increased advantage of the whole length of the tube by taking the observation end on. By this means a greater intensity of light is obtained, and a resulting greater delicacy of observation. This is one of the greatest advances in modern work.

In the solar spectrum the black lines have been shown to be due to the light of the incandescent elements passing through an atmosphere of their own gas, and by compelling similar conditions to exist I can here show you this absorption with a sodium flame.

Spectrum analysis is now being largely used for the detection of poisons, such as cases of death caused by coal gas, carbon monoxide, thallium, etc., and among its other applications may be mentioned its use in determining the shades derivable from a mixture of several aniline colors, etc.

By means of spectrum analysis we are able to tell that the sun spots, which at one time caused so much alarm, are craters, from which large hydrogen jets are burning; that the moon and Venus have no atmosphere, while Jupiter and Mars have atmospheres; that there is aqueous vapor in Saturn; that the nebulæ are mere gaseous collections; that the comets contain carbon; that the colored stars are so colored because a portion of their light is obscured by absorption caused by gaseous elements, present in the stars, etc.

To fully describe the many wonders revealed by spectrum analysis many nights would be required. This evening, at best, I have only been able to give you a very general and hasty glimpse at the subject. We can well understand the benefits now derived from the patient hard work of the German, Professor Bunsen, who gave the spectroscope birth. He is now far advanced in years, and, although honors have been heaped upon him at home and abroad, he is still the same simple-hearted, one-minded, lovable man. His students adore him, and well they may, for he has given his life for the advancement of their interests, and his only desired reward is their good.—*Edinburgh Photo. Soc., Br. Jour. of Photo.*

[Continued from SUPPLEMENT, No. 647, page 10337.]

MANUFACTURE OF PHOTOGRAPHIC SENSITIVE PLATES.

THE machine for coating photographic plates was described in the first portion of this article; three old-fashioned tables for hand-coated plates are also in use at the works of Messrs. Marion & Co. at Southgate. The three tables are each about 36 ft. long; they are made of slabs of slate, accurately leveled, and stand side by side, occupying nearly the entire length of the room. A pair of endless cords move along the top of each table at a speed of one foot in ten or fifteen

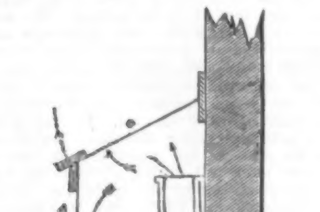


FIG. 11.

seconds, and each plate as coated is laid upon the cords, the accurate leveling of which permits the gelatino-bromide emulsion to set evenly, while the plate is being carried out of the way of the operator and through a cooling chamber a little in front of him. At the farther ends of the tables the plates are picked up by assistants, restored in racks, and then sent up the lift to the drying rooms. Each workman employed in coating has a batch of cold glass plates before him; he raises one plate at a time by means of a pneumatic holder, the essential part of which is a "sucker" made

FIG. 12.

of India-rubber, then he pours the emulsion over the plate from a teapot-like vessel, the low level of the bottom of the spout of which causes the emulsion to be taken from near the bottom of the vessel, where it is free from air bubbles. A lamp giving forth non-actinic light is placed over each table above where the coated plates are first placed on the cords. A good workman coats five or six plates per minute easily, although some skill is required to cover a plate evenly to the edges without spilling any of the emulsion or allowing it to flow over the back of the glass. The tables are of high level, so that the operators do not have to stoop in their work, and the plates are coated at about the level of the eye.

In the two drying rooms, directly under the roof of the building, as described in our last, the plates with the set gelatine emulsion upon them are dried in a steady current of air at a temperature of about 80° Fah. The air enters one side of each room through 6 in. siphons 2 ft. apart near the floor, as represented in Fig. 11, and passes over 4 in. hot-water pipes; A B is a muslin screen to filter out the coarser dirt and dust in the air, and C is a wooden top or lid which gives access to the interior of the arrangement. The ventilators, one of which is shown in Fig. 12, in the ridge of the roof, surmount two upcast shafts, one from each drying room; the tops of the ventilators are so made that there is no downward draught through them, whichever way the wind may blow.

Fig. 13 represents the chief developing room and

FIG. 13.—A MODEL DEVELOPING ROOM.

laboratory of the establishment, from which daylight may be immediately shut out by closing its solitary window, seen on the right. At the farther end of the room is the sink, fitted chiefly for the development of photographs, and a developing dish on a wooden grid is shown in the engraving; this grid is virtually the top of a pendulum beating true seconds, so that the dish is automatically rocked during the development, and the rapidity of the appearance of the image on the plate is timed by its own motions. In good photography such information as to time is useful, and it is exceedingly convenient to have an automatic rocker for developing dishes, for some of the best pictures are often produced by slow development. Another pendulum beating true seconds hangs in the form of a rod from the ceiling over the sink. A flap table is placed in front of the sink, and is represented raised in the engraving; a tank in the foreground to the right has also a flap table in front, shown in the cut as hanging down; these tables are useful for the manipulation of camera slides and other articles. The water tap in use over the sink is an ingenious improvement by Mr. Cowan upon ordinary taps, and is represented in Fig. 14. It consists of an ordinary swing tap which cuts the water off when it is pushed back against the wall, and turns it on when it is pulled forward; the improvement consists in the rotatable nozzle, which when turned downward enables the operator to readily fill a bottle with water; when, however, it is turned upward, the water escapes downward through a rose, and falls in thin streams suitable for washing photographic plates.

The lamp for giving the yellow light by which photographic plates are developed is shown, half open, in Fig. 13, at the back of the sink, and its nature may be explained by the accompanying cut, Fig. 15, in which A B, the front of the lamp, consists of three or four thicknesses of dry tissue paper, sunflower yellow in color. The sheets are not gummed or pasted together where the light shines through them, translucency rather than transparency being desired. The curved sides, B H A, are of metal painted over with chrome yellow. The light, E, which may be that of a candle or gas flame, in the case now under notice is that of an incandescent electric lamp, none of the di-

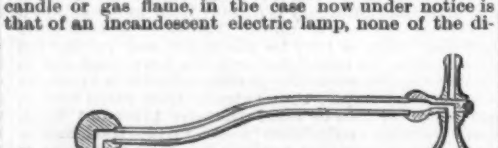


FIG. 14.

rect rays from which can reach the front of the lantern, A B, because of the intervention of the metallic reflector, K; thus the rays have first to fall upon the light yellow dead surface, H, and those reflected therefrom find their way in part through the translucent yellow screen, A B. The philosophy of the arrangement is that when the white light from E falls upon the screen, H, the blue and violet rays, which chiefly act upon ordinary photographic films, are to a considerable extent absorbed; the more or less yellow rays now thrown off by H have any of the more refrangible rays still mixed with them cut off either entirely, or sufficiently for practical purposes, by the translucent yellow screen, A B. Until within the last few years an erroneous theory of development-room lighting was put forth in text-books, namely, that ruby light was the best for the development of photographic plates, because the rays of the red end of the spectrum act least upon ordinary bromide of silver. This theory caused multitudes of photographers to work in a miserably bad light of low refrangibility, in which some of them injured their eyesight. The theoretical error consisted in the overlooking the physiological side of the problem. The human eye is greatly more sensitive to yellow than to red light, consequently in a yellow light of given intensity can see better than in a stronger red one, and when the balance of advantages is struck, a proper yellow light is found to be the best for the development of ordinary photographic plates.

The quality of plates is tested in this room by means of a little glass screen covered with spaces graduated from complete transparency to complete opacity; the plate is exposed behind this screen at a standard distance from a standard gas flame, and the number of areas on the screen of which a photographic image can be obtained in, say, thirty seconds, is ascertained. The more sensitive the plate, the greater is its power of photographing the more opaque areas of the interposed glass screen. A positive photograph of a good negative is sometimes taken on the same plate at the same time; this, coupled with the sensitometer test, gives information as to the general quality of the plate.

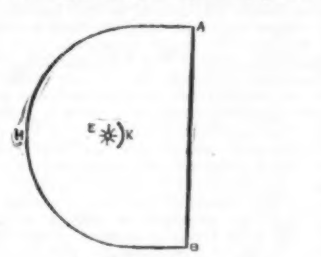


FIG. 15.

We come now to the operations connected with the manufacture of a photographic emulsion, in relation to which every large manufacturer keeps his formulæ to himself, since upon them depend the distinctive characteristics of his particular brands of plates. There is, however, no great secret in emulsion making, and formulæ innumerable have been published. Perhaps the best plan to adopt, before describing Messrs. Marion's large appliances, is to tell how to make a small quantity of emulsion according to formulæ given by a trustworthy authority, Mr. W. K. Burton, Professor of Sanitary Engineering, Tokio, Japan, in his handbook of "Modern Photography"—Piper & Carter, London, 1886. The following solutions are made:

A.

Nitrate of silver	200 grains.
Distilled water	3 ounces.

B.

Bromide of potassium	160 grains.
Nelson's No. 1 gelatine	40 grains.
Distilled water	2½ ounces.
A 1 per cent. mixture of hydrochloric acid and water	200 minims.

C.

Iodide of potassium	12 grains.
Distilled water	½ ounce.

D.

Hard gelatine, such as Heinrich's	300 grains.
Water	Several ounces.

B and D are allowed to stand till the soaked gelatine is thoroughly soft; all the water is now poured off D, and as much as possible then squeezed out of the gela-

tion. The pots containing A and B are next raised in a hot-water bath to about 160° Fah., when B is poured into a hock bottle, the red-colored glass of which helps to give protection from actinic light, and from this time all the operations are performed in a feeble yellow illumination.

A is now poured in five or six stages into B, which latter is well shaken after each addition, and a very thorough agitation is given at the end. C is next added, and the whole again shaken. We have now an emulsion of bromide and iodide of silver in gelatine,

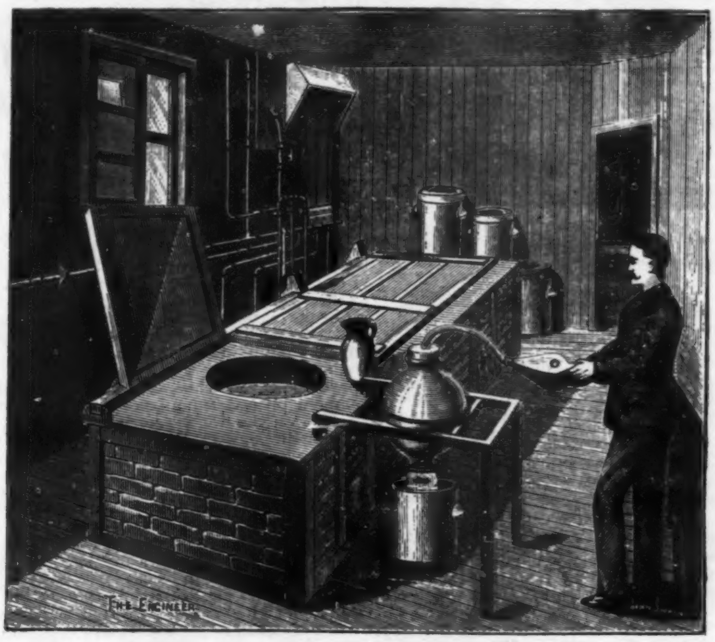


FIG. 16.—EMULSION PREPARATION ROOM.

plus the nitrate of potassium in solution, formed by double decomposition. The whole is poured into a covered stoneware pot, which is placed in a saucepan of hot water, and the latter is raised as quickly as possible to boiling point over a ring burner; the pot should remain in the boiling water about twenty minutes. The soaked gelatine D is then added to the emulsion and stirred in, after which the pot is put in a cool, dark place for one or two hours to set, or it may be left there a few days if more convenient to the operator. Next it is removed by the aid of a silver spoon, and placed upon a piece of clean, coarse canvas free from grease, through which it is squeezed under water in fine shreds into a hair sieve standing under the water. The shreds are washed in this sieve in running water, or by frequent changes of water, for at least half an hour, to remove the nitrate of potassium and all other soluble matters, and the granulated emulsion is frequently stirred with a thick glass rod having a rounded end. The sieve is then raised from the water, is placed in a slightly tilted position, and allowed to remain for upward of half an hour to let much of the water drain off. The emulsion is then remelted, filtered through several folds of cleansed linen, half an ounce of pure alcohol is next added, and the emulsion, which should amount to twelve or fourteen ounces, is then ready for coating the plates.

Fig. 16 is a view of the appliances at Southgate for treating and filtering gelatine emulsions. Three cast iron vessels, supported by brickwork, have ring gas-burners underneath; they are partly filled with water, in which are placed the stoneware vessels containing the emulsion, glue-pot fashion. By an arrangement of pipes, a man standing at one end of the room can turn the gas up or down, can let cold water into the iron vessels, or let the hot water out. The brickwork is "dry"; no mortar is used, so that, if necessary, the whole can be removed and set up in another part of

FIG. 17.—HENDERSON'S EMULSION WASHER.

the building. Filtering operations are also figured in the engraving, the emulsion being driven through the filtering medium by the pressure of air from a bellows. Wash leather is one of the best substances for the purpose; it is washed in several changes of warm carbonate of soda to get out the liberal supply of oil used in the dressing, then it is washed in several changes of warm water, not too hot. Fine linen cleansed in the same way answers the same purpose. Several successive filterings do not interfere with the characteristics of the emulsion, for the bromide of silver held in suspension in the gelatine passes with it through the medium like so much milk.

Fig. 17 shows a useful appliance for washing emulsion in daylight, invented by Mr. A. L. Henderson, and made of stoneware at the Doulton pottery works. It consists of a light-tight outer vessel with an inlet for water at the top, and a movable pipe outlet at the bottom. The amount of elevation of this outlet pipe gives a level below which the water in the interior cannot fall; the upper outlet pipe prevents the rise of water above a desired level. The hair sieve in the interior is supported on a shelf a few inches above the bottom of the vessel. These vessels, with the large quantities of emulsion dealt with by Messrs. Marion & Co., are used only for experimental purposes, and sometimes several of them are in use at once. For washing large quantities of emulsion a wooden trough, 7 ft. long by 2 ft. square, is used, with a straining screen of several thicknesses of muslin near one end. The overflow of water escapes through an open pipe into a partitioned vessel below, which itself is furnished with an overflow outlet. The lower vessel is applied to catch any fine deposit of bromide emulsion which may find its way through the muslin, and sometimes a layer an inch deep is thus saved. In this trough from 50 to 60 gallons of emulsion can be washed at one time. Sometimes the emulsion is not washed, but separated by means of the centrifugal machine.

Another branch of the establishment is the preparation of the albumenized paper upon which the ordinary photographs so well known to the public are printed. The albumen is bought from the importers, the yolks having been by them already separated for the dressing of gloves, the use of confectioners, and other commercial purposes; the other portion is bought by the gallon, and one gallon of albumen represents about 160 eggs. It is delivered in covered jars. At the Southgate works it is beaten up in a churn in quantities of about two gallons at a time until it stands a complete froth, which is then moved into pans and allowed to settle as a liquid, not "stringy," as in the case of the original substance. It may then be tinted by means of aniline dyes to any color required. Then it is sent up to the albumenizing room, where girls skilled at the work float the sheets of paper upon it for a moment, letting each sheet down so as to push the air bubbles on the albumen before the front edge of the sheet, then raising the sheet by a steady, quick movement, in such a way as to prevent the albumen running into ridges upon the paper; the sheet is then pinned to a horizontal rail, two somewhat heavy American wooden clips are attached to the lower corners to prevent the paper from curling, and the bulk of the surplus albumen partly drains and is partly wiped off from the lower edge of the sheet. In the middle of the large room are two erections which may be described as "sheds" with hot water pipes along the bottom, and curved metallic sheets to catch the drippings of albumen. One of these sheds is somewhat open, as represented in Fig. 18, the other is closed. The sheets, pinned upon rectangular rods with T pieces at each end to keep the sheets 6 in. apart, are pushed with each addition along ledges in the moderately warmed shed, and afterward passed into the more highly warmed closed shed. From the latter they are removed through openings like these represented in Fig. 19, at the top corners of which will be noticed rounded holes to admit the hands of the

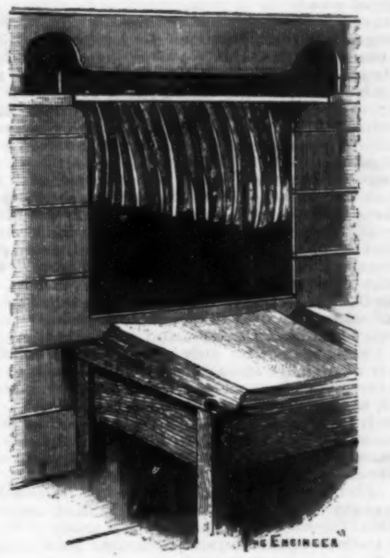


FIG. 19.—AN EXIT ORIFICE OF DRYING SHED.

assistants. The tops of the roofs of these sheds being always dry and warm form useful platforms on which to store photographic goods liable to be damaged by damp. The dried sheets of albumenized paper are then flattened out by girls with white gloved hands, and rolled upon cardboard cylinders, albumenized side outward; they are left thus for some hours, usually all night, to take the curl out of them, their edges are then trimmed in the cutting machine, and they are afterward packed for sale.

A 4 horse Otto gas engine, by Crossleys, drives the coating machine and centrifugal separator, as well as a small dynamo giving the current required for twenty incandescent lamps. This true history now draws to a close, and its chief points of interest are that Cadett's coating machine is perhaps the first large one for preparing photographic plates which has been described with illustrations in any public journal, also that Messrs. Marion & Co.'s works at Southgate are model ones and quite new, planned under the direction of Mr. A. Cowan, whose practical ability has long been recognized by experienced photographers. Messrs. Marion & Co. have works in Paris for the manufacture of photographic mounts and other requisites of photographers; indeed, their firm is possibly the largest one in existence in connection with what the late Mr. Henry Greenwood christened the "art science."

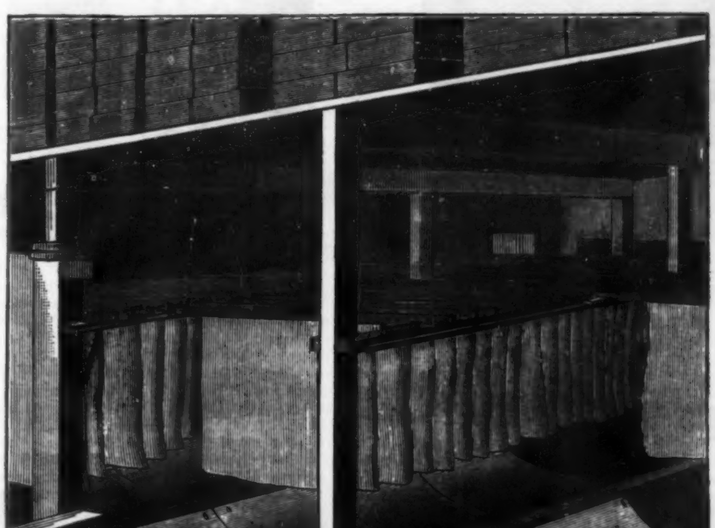


FIG. 18.—ALBUMENIZED PAPER DRYING CABINET.

Another point of interest is that the blue process so well known among engineers, originally devised by Sir John Herschel, was first introduced commercially by Messrs. Marion & Co. as the ferro-prussiate process, by which name it is denoted to this day.—*The Engineer.*

ON STEREOSCOPIC PHOTOGRAPHY.*

By A. STROH.

IT is a matter of surprise and regret that so beautiful an invention as the stereoscope by Sir Charles Wheatstone, and its later modification by Sir David Brewster, should have shared the fate of other novelties, and should have been (at least as a popular instrument) a nine days' wonder. Probably the stereoscope will never become popular again—unless, perhaps, some new departure is made in it.

What is, however, more surprising is that amateurs do not more frequently avail themselves of the means at their command, through the stereoscope, of giving certain charms to their productions which they could not obtain in any other way—such as the effect of relief and solidity of the objects represented, as well as depth of scene.

I have heard it said that the reason why stereoscopic photography is not practiced more often is that it gives too much trouble, and requires more time than the amateur can generally bestow upon it. If this be the only disadvantage, then I think I can show that in order to produce a good stereoscopic slide no more trouble nor time need be expended than in making a half plate or quarter plate picture, if the proper means be at hand.

There is, however, one other obstacle, and that is that at the present time there are but few stereoscopic cameras in the market, and perhaps none at all of the detective class. But there can also be no doubt that makers of photographic apparatus will soon produce cameras and other necessaries, if they find that there is a demand for such articles.

The Camera.—The simplest way of obtaining a stereoscopic camera is by taking out the rising front of an ordinary half plate camera, and replacing it by a front with two lenses. The only other arrangement necessary is a partition inside the camera, which divides it into two compartments, and which can be made of thin wood, cardboard, or other suitable material.

Much can be done with such a camera, but since we are now moving in the right direction by using detective cameras for instantaneous work, a stereoscopic detective camera is what is really wanted.

In order to make a camera of the last named description, many conditions have to be fulfilled, and on this account, together with the fact that many of the parts have to be in duplicate, such a camera must necessarily be more or less complicated.

Having felt a strong desire to possess a camera of this class, and not being able to procure it in any other way, I have constructed one myself, a description of which I trust may be interesting to the members of the club.

This camera (Fig. 1) consists externally of a square box without any projections excepting a leather strap to serve as a handle. Its dimensions are 9 in. by 8 in. by 6¾ in. The back consists of a slide, which is drawn out when plates have to be changed. The plates themselves are in tin carriers, eight of which are contained in a compartment provided for them in the upper part of the box. The plates I use are the usual stereoscopic size—viz., 6¾ in. by 3¼ in. Each plate after being exposed is drawn down with its carrier into a lower compartment by a button or knob, which is concealed in the bottom of the box.

This shifting arrangement for the plates will be readily understood by those who are acquainted with the working of Samuel's patent back, for it is in fact nothing more or less. Instead of trusting, however, to the tin carriers for the exact position of the plate which is to be exposed, two brass supports are provided at the sides of the compartment, against which the face of the plate itself rests. In addition to these there are four movable supports touching the face of the plate in the four corners. These are attached to levers, which can be moved simultaneously by a cam in connection with an index concealed in the side of the box. The latter arrangement is used for focusing. It has the effect of pushing the plates further away from the lenses, the extent of movement being controlled by the cam and index named.

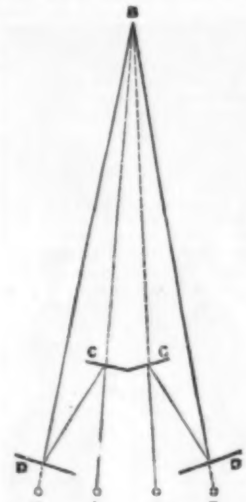


FIG. 7.

Suspended by hinges in front of the box is a flap, which has to do duty in three ways. When closed, it protects the lenses from mechanical injury, and also keeps the light from them, while the shutter is being reset for exposure. When open, it forms a screen against top light. It is also in immediate connection with the catch or trigger of the instantaneous shutter, which it releases as soon as it is opened sufficiently.

The shutter works between this flap and the lenses, and consists of a thin leather screen or curtain, with two holes corresponding with the lenses, through which the exposure is made. The upper extremity of this leather shutter is fastened to a light revolving cylinder, mounted just above the lenses. The latter contains a spring, which can be wound up to a more or less degree by an index lever at the side of the box. (See Fig. 2.)

The action of this shutter is identical with that of an ordinary spring roller window blind. When it is being set for action, it is drawn down by a piece of catgut, which passes through the bottom of the box, and has a little knob at its end. There is a separate little spring barrel for the catgut, which winds it back into the box when released, while the shutter is prevented from being rewound on its barrel or cylinder by a catch, which can only be released by lifting the flap as above described. The time of exposure can be varied by this shutter from one-twentieth to a sixtieth of a second, according to the tension given to the spring in the cylinder.

Immediately behind the shutter are the lenses, which are a pair of Dallmeyer's rapid rectilinears, having an equivalent focus of 4 in. The distance between their axes is 3 in. They are mounted on a rising front, which can be moved up and down by an Archimedean screw, the end of which passes through the bottom of the box and carries an index.

The stops are all in one brass slide passing through both lens tubes, which are slotted to receive it. There are eight apertures in the slide, four for each lens. A spring catch is provided for locking the slide in four positions, in each of which two corresponding apertures are concentric with the lens tubes. The value of the apertures is $\frac{F}{7}$, $\frac{F}{10}$, $\frac{F}{14}$, and $\frac{F}{20}$. The stops are shifted by an index in the bottom of the box; attached to this index is a pinion, which, by means of a rack and a lever, communicates its movements to the brass slide.

The only other arrangement to be described is one which enables the operator to make time exposures. For this purpose a catch is provided in the same recess, which contains the index for the regulation of instantaneous exposures, which will lock the shutter when the two holes in it are opposite the lenses. The exposure is then made by lifting the flap to the full extent, in which position it will remain by itself during the exposure. It being necessary in such cases to place the camera on a stand, a brass socket is provided in the bottom of the box for a screw.

It will be seen by the above description that the box, or camera, contains all the elements necessary for taking any variety of subjects in or out of doors.

It may also be mentioned that the whole of the internal mechanism is attached to a light framework, which will slide out of the box when required, after simply opening the back. There are no bellows nor any other arrangement for reducing the size of the camera when not in use.

It will also be noticed that care has been taken to construct this camera in such a manner that all the most essential adjustments are controlled from below. This is a most convenient arrangement, as the levers and indexes are out of sight, and yet always ready for action. Even the operator does not want to see them, for his sense of touch suffices to work them. The indexes for focusing and altering the time of exposure are necessarily in the sides of the box; but they are not often required, and are, therefore, hidden by thin sliding covers.

With this camera, as with any other detective camera, an object or view has to be taken without seeing it first on a ground glass screen. Therefore, it is convenient to have a little view meter, which will help the operator to take up his position at the right distance from the object he is about to take. All that is necessary for this purpose is a little tube about 1 in. in diameter and ¾ in. long, with a thin plate fixed to one end, in which is a hole about ⅜ in. square. When the open end of the tube is placed closely against the operator's eye, he can see through the square hole at the other end of the tube how much of the subject is included in his picture. He will also fix in his mind the center of the

* Read at the Camera Club April 5.—*Engineering.*

FIG. 1.

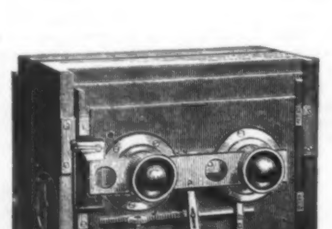


FIG. 2.

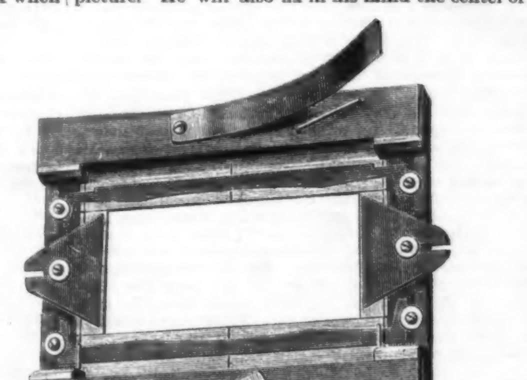


FIG. 4.

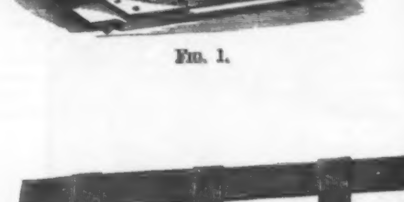


FIG. 3.

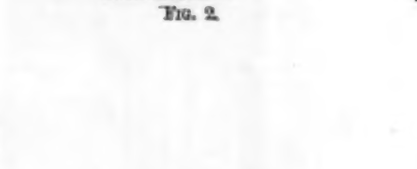


FIG. 6.

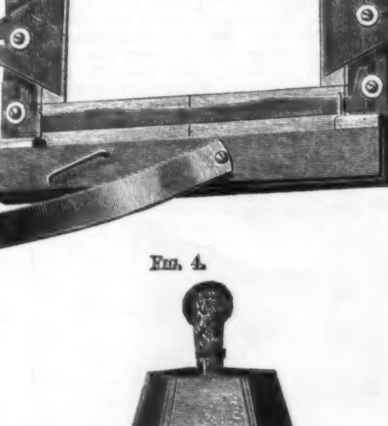


FIG. 5.

STEREOSCOPIC PHOTOGRAPHY.

picture against which he has to direct his camera, and he will also see, by imagining a horizontal line through his picture at the same level where he stands, whether it is advisable for the front carrying the lenses to be raised or lowered. He makes the necessary change; the shutter and stops are supposed to have been set already; and all that remains to be done is to direct the box toward the central spot in the intended picture, lift the flap until he hears the shutter act, and the exposure is made. He then pulls the button or knob for changing the plates, resets the shutter, and all is ready for another exposure.

The focusing arrangement is not often required; it is, however, useful in cases where one wishes to take a near object or group. For this purpose it answers very well to ascertain how many paces are required to walk from the object to the spot from which the photograph is to be taken, and to set the focusing index to that number, the scale being divided for the purpose.

Printing.—In printing from a stereoscopic negative, two important conditions have to be considered. In the first place, it must be borne in mind that, through the well known course of things, the two pictures on the negative are reversed—that is to say, the right hand side of the view is on the left in each picture, and *vice versa.* A print from a stereoscopic negative has therefore to be divided in the middle, and reversed in mounting. The second condition is that care should be taken to mount the two pictures in such a manner that the mean distance between the same object in each of the two pictures be not more than 2⅝ in. If they are too far apart, most persons fail to combine the two pictures in the stereoscope, and therefore they cannot see the stereoscopic effect.

It is true that stereoscopes vary, and so do observers' eyes, and the distance between them; it is, therefore, impossible to make stereoscopic slides to suit everybody's sight. A happy medium has therefore to be adopted, and the condition given above I believe to be that medium.

A well known method of printing from a stereoscopic negative is to cut the sensitized paper double the length of one print, and fold the two ends back, so as to meet at the middle of the strip; then print both sides while the paper remains folded. The strip may hereafter be unfolded and cut through the middle, whereby two stereoscopic prints will be the result, each of which may be mounted in one piece.

However ingenious this method may be, it has its disadvantages, and can only be carried out when the two pictures on a negative are perfectly upright. But, when working with a detective camera, on account of the difficulty of holding it in a perfectly vertical position, the resulting pictures are seldom quite upright, which is a matter of indifference, provided one has the means of making them upright afterward.

For this reason, I have adopted the plan of cutting the negative in two halves, and afterward fixing them, reversed of course, in a printing frame constructed for the purpose. The advantage of this plan is that when the two halves of the negative are once properly adjusted in the printing frame, any number of prints can be taken from them without further adjustment in mounting or otherwise.

For the purpose of cutting the negative I have contrived a very simple tool. It consists of a thin board, a trifle larger than a negative, and what may be called a triple T square. (See Fig. 3.)

The negative is placed face downward on the board with a white paper between, and the T square over it. It is then necessary to shift the negative so that the vertical outlines of building, or other objects in it, are parallel with the blades of the T square. Three cuts are then made with a diamond along the three blades, the middle cut dividing the negative exactly between the two pictures.

It will be seen that by the adoption of this device, besides the two pictures being made upright, the distance between the similar objects in a finished print is determined by the distances between the three blades of the T square. If, therefore, the latter be once properly adjusted, any number of negatives from the same camera may be divided without paying further attention to adjustment.

The printing frame, in which the two halves of the negative have now to be placed, is an ordinary half plate frame with a few additions.

The first of these is a piece of thin plate glass for a support fitting the frame. Over this is laid a mask of thin cardboard, also fitting the frame accurately, having a rectangular opening of 5¾ in. by 2⅞ in. (These dimensions may have to be varied slightly for negatives taken in different cameras.) Next to the mask are four adjustable slides, as shown in Fig. 4, for the purpose of holding the two halves of the negative in position. These slides are made of sheet zinc, and must be less in thickness than the glass of the negatives.

Transparencies.—We now come to the most pleasing part of stereoscopic photography, which is the production of transparencies. These can be made with the aid of a stereoscopic copying camera, the advantage of this method being that the negative can be preserved as a whole, for the inversion of the two pictures is corrected by the second inversion which takes place in the copying camera.

A copying arrangement of this kind is, however, an expensive item. It is, moreover, much more convenient to obtain transparencies by contact printing. The printing frame above described is admirably suited for the purpose.

It must be borne in mind that a transparency made by contact printing has to be viewed with the film side toward the observer, otherwise it will be seen reversed. A thin glass must be put over it for protection, and in a transparency thus made it is impossible to apply the usual ground glass at the back without adding a third glass, which would be objectionable.

A transparency without ground glass, as just described, when viewed in a stereoscope, also without ground glass, while the same is held over a sheet of white paper, is, however, all that can be desired for effect, and is the cheapest and simplest form of transparency.

At the same time, it is not always convenient to hold the stereoscope over a white paper, and in that case the coarse ground glass in the stereoscope, and the fine ground glass at the back of the transparency, are necessary for the diffusion of light.

Transparencies of the latter description can be obtained by proceeding as described; but instead of using plates of the usual make, to have special plates prepared of ground glass with the film on the polished side.

The transfer papers lately introduced, such as Eastman's transferrotype, make also very good stereoscopic transparencies. The paper in this case is printed by contact, and after development squeezed on to a glass on which the film remains after the removal of the paper support.

Looking at the film side of such a transparency, the picture is reversed, and in order to see it like its original it has to be turned round so that the film is at the back of the glass. This is, however, precisely what is wanted for a stereoscopic transparency, for all that remains to be done is to put a plain or ground glass behind it according to taste.

Multiple Stereoscope.—I have now to say a few words respecting the best way of showing a collection of stereoscopic transparencies to a number of persons. Any one possessing a large number of transparencies arranges them, naturally, in a certain order, in which he desires to show them. Or it may be for the purpose of easily finding any particular one or other. He can certainly have several stereoscopes, and hand them round with pictures, but the consequence of such a plan is that the latter will not be returned to him in the same order as given out, and his collection will be subjected to confusion.

Bearing in mind this inconvenience, and also the fact that all attempts to enable a number of persons to view the same stereoscopic picture simultaneously have failed, I have constructed what may be called a multiple stereoscope, which I find exceedingly convenient for exhibiting transparencies. (See Fig. 5.)

It consists of a light five-sided box, with five stereoscopes arranged around it. It could, of course, be constructed for any number.

One of the sides of the box opens on hinges, and gives access to the interior, where there is a framework capable of revolving on a central pivot. This framework is so constructed that five transparencies can be placed on it, so that each of the latter is viewed through one of the five stereoscopes. The framework surrounds a white disk, against which the stereoscopes are directed, and which is illuminated by a lamp suspended in the center. This disk revolves with the framework, and is provided with five notches, into which engages a spring lever, locking it in five positions where the transparencies or pictures are opposite the stereoscopes.

The change of pictures takes place through the side of the box which opens, and after each change the spring lever is withdrawn, while the disk is advanced one-fifth of a revolution, so that each picture has to travel round from one stereoscope to the other.

When constructing this instrument, I soon found, however, that it was extremely unpleasant and even painful to the eyes to look in one of the stereoscopes while the change of pictures took place. I had, therefore, to provide all the lenses with shutters, which close automatically during each advance of the inner framework.

Binocular Perspective.—Without exactly entering upon the theoretical field of binocular vision, I have to say a few words respecting it, in order that we may recognize the best conditions for the production of stereoscopic pictures.

If we look at an object with both eyes, the line of sight of one eye forms an angle with that of the other, and the one eye necessarily receives an image of that object slightly different from that seen by the other eye. Upon this angle of vision, as it is called, or, in other words, upon the difference of the images received by the two eyes, mainly depends our estimation of depth of solid objects, as well as distance between objects in the direction of the line of sight.

The nearer we are to an object, the greater is the angle of convergence of the lines of sight, and the better are we able to judge of the depth and solidity of such an object. But as the distance between the observer and the object increases, this angle diminishes until the lines of sight become almost parallel. The image in one eye is then practically identical with that in the other, and under these circumstances we no longer see what is called binocular perspective.

It is for this reason that distant scenery seldom makes a good subject for the stereoscope; the two pictures in such a case being so nearly alike that we fail to obtain thereby stereoscopic relief, or perspective. We should, therefore, choose subjects at not too great a distance for stereoscopic pictures, or, if we take distant views, care should be taken to have a foreground, without which our picture will look flat and uninteresting.

In order to obtain the effect of binocular perspective in the stereoscope, as we see it when we look at natural objects, we have to consider two distinct factors. These are the focal length of the lenses of the camera, and the distance between them.

Taking the latter condition first, a glance will tell us that we cannot do better than adopt for the separation of our lenses the same distance which separates our two eyes, which is, on an average, 2½ in. There are, however, reasons for making the distance between the lenses somewhat greater, since the pictures cannot be larger than 2½ in. if the lenses are only that distance apart. Pictures somewhat larger can be obtained by increasing the distance between the lenses, the necessary consequence, however, being distortion in the shape of exaggerated perspective.

If not carried too far, this exaggeration of perspective is permissible, and is almost necessary, for many persons cannot appreciate binocular perspective in the stereoscope at all unless it is exaggerated, and very few persons indeed can detect a moderate exaggeration of perspective.

Our power of correctly estimating distances in the direction of the line of sight by binocular vision is an acquired faculty, the extent of separation of our eyes being arbitrary, and we should be able to do it as correctly if our eyes were further apart from each other.

If it were possible for the distance between the eyes to be suddenly augmented, we should for some time see everything in exaggerated perspective, until we should gradually associate again in the mind the true dimensions of things with their images, as seen by our eyes. If, then, the distance between our eyes were suddenly restored to its former condition, we should see for a time everything in flattened or diminished perspective, until we again became used to the altered state of things.

In order to verify this fact experimentally, I have constructed an instrument which proves it in a striking manner. A A (Figs. 6 and 7) represents the two eyes of an observer looking in the direction of an object, B. The view is intercepted by reflectors, and the image of B can only be seen by the double reflection from the reflectors C C and D D. The result of this arrangement is the same as if the two eyes were looking from the points E E, and, therefore, a much larger angle of vision is obtained.

The instrument is so constructed that the distance between the reflectors, D D, can be varied up to about 12 in., so that an observer has thereby the means of gradually increasing his angle of vision. Any one looking through this instrument at another person's face, for instance, at about 4 ft. distance, will see the face become more and more elongated in the direction of the line of sight, as the reflectors are more and more separated from each other.

If, after gazing intently for a minute or two at this exaggerated perspective of the face, the observer suddenly looks over the instrument at the face direct, the contrary effect is produced, and for a short time the face appears perfectly flat, and without any perspective.

From what is said above, it appears that it is by no means necessary to adopt the distance between our eyes accurately for the extent of separation of our lenses in constructing a stereoscopic camera, although we must be guided to some degree by that distance. But there is nothing to guide us, so far as I know, in determining what should be the focus of our lenses, except trial or experience; and I should expect to find considerable diversity of opinion on this point. All I do is to give my own experience.

I have experimented with lenses varying in focus from 2½ in. to 10 in., and have come to the conclusion that lenses with an equivalent focus of 5 in. and a distance of 2¾ in. between their axes are about the best proportions when exaggerated perspective is not desired. For a moderate exaggeration, however, the distance between the lenses may be increased to 3 in., and their focal length may also be reduced to 4 in.

Lenses with too long a focus have the disadvantage of taking very little subject in the limited field of a stereoscopic slide; they have, moreover, the effect of diminishing perspective; while lenses with too short a focus certainly include more subject, but not without the consequent disadvantage of over-exaggerating the perspective. It is true that the disadvantages of too long a focus may be compensated by a much greater distance between the lenses; but in that case, the relation between binocular and geometrical perspective is no longer such as we are accustomed to. The result, therefore, must be more or less unnatural.

Volumes might be written on this subject; but I trust what I have said may prove useful to those who are thinking of taking up stereoscopic photography, and if by bringing this subject before the Camera Club I have stimulated, even to a small degree, a revival of this beautiful and fascinating branch of photography, my object will have been attained.

CRYOLITE MINING.

I TALKED with two old-time sea captains the other day. One of these hardy navigators was a tall, full-faced, well built, benevolent looking man, Captain Louchlan McKay. In command of the Sovereign of the Seas, one of the famous old clippers that once made Americans proud of their merchant marine, Captain McKay left New York for San Francisco in August, 1851; the freight money amounted to $85,000—a very large sum to-day; a barrel of flour in San Francisco in those days of gold fever sold for about $45. Off Valparaiso, in a storm, Captain McKay's ship was dismasted but rigged up again and reached her destination in 102 days, which was a quick passage. Discharging her cargo, the gallant clipper sailed for Honolulu and loaded with oil for New York, and made the extraordinary time of 82 days.

For 10,000 miles she sailed without tacking or wearing, and in ten consecutive days she made 3,300 miles. But the days of the noble old clippers are gone, and I went to see this veteran of the sea about the ships that trade with Greenland. His are the only vessels that go regularly to the far-off land of Kane. They go out in ballast, for although Greenland imports wheat, brandy, coffee, sugar, tobacco and fire wood, it is not from this country. They bring back a mineral termed cryolite, which they obtain at a port called Ivigtut, on the southwest coast of Greenland. It is a bleak country, even in the short summer, during two months of which, June and July, the sun is always above the horizon. Mosses, stunted shrubs, dwarfish trees and huckleberry bushes are about the only vegetation, and the bare mountains in the grip of the great glaciers and the generally dead and desolate aspect of the country make it appear as strange and unreal as that gray corpse of a world the moon.

Cryolite looks like ice, and hence the name signifies icestone. It is all taken to Philadelphia, and is used in manufacturing soda, alum, lye, porcelain piano keys, door knobs, clock dials, and other articles. The seven barks in the trade each carry about 800 tons of this mineral and make fourteen voyages in a year. Last year they brought 8,400 tons to this country. Those at Ivigtut are the only known mines in the world. Specimens of this mineral have been found in the Ural Mountains and on Pike's Peak, but no other actual mines but those in Greenland are known. It takes 20 days to go to Ivigtut, and 30 to return. The Danish government owns the mines, and they are worked by a company that pays a royalty to that government.

The vessels in this trade are built unusually strong in order to withstand the rigors of that frozen region; they have steel plates on the bow, iron on the stem or forward part of the vessel, double planks on the sides, and are filled in with timbers, and yet three years ago one of the staunch barks was lost in the ice, and one that reached the open sea was never afterward heard from. The danger is not so much from icebergs as from the great blocks of floating ice or "floe ice." For eight months of the year, or in the winter season, it is a continuous night, and navigation is especially dangerous. During the four summer months of the year vegetation makes rapid progress, but it is of a dwarf-

ish character, and the tallest trees do not exceed 18 feet. The greatest recorded cold of Greenland is 68° below zero, and the greatest heat 53° above, while the average for the year is 3° above zero.

The little port whence the supply of cryolite is obtained has a population of about 150 miners and as many Esquimaux. It is not a place that invites civilization, and the natives, debauched by the whisky of the Caucasians till the sale of that beverage has been interdicted, probably think they do not lose much by living in what the civilized usually regard as a lost land, captive in the grasp of the Arctic terrors that guard the awful approaches to that mysterious and fatal objective point of human ambition and daring, the north pole.—*O. W. Riggs, in Philadelphia Press.*

ANTAGONISM.*

By Sir William R. Grove.

Some months ago, shortly after I had resigned my office of judge of the high court, I was expressing to a friend my fear of the effect of having no compulsory occupation, when he said by way of consolation, "Never mind, for 'Satan finds some mischief still for idle hands to do.'" You may possibly in the course of this evening think he was right. I have chosen a title for my lecture which may not fully convey to your minds the scope of the views which I am going to submit to you. I propose to adduce some arguments to show that "antagonism," a word generally used to signify something disagreeable, pervades all things; that it is not the baneful thing which many consider it; that it produces at least quite as much good as evil; but that, whatever be its effect, my theory—call it, if you will, speculation—is that it is a necessity of existence, and of the organism of the universe so far as we understand it; that motion and life cannot go on without it; that it is not a mere casual adjunct of nature, but that without it there would be no nature, at all events as we conceive it; that it is inevitably associated with unorganized matter, with organized matter, and with sentient beings.

I am not aware that this view, in the breadth in which I suggest it, has been advanced before. Probably no idea is new in all respects in the present period of the world's history. It has been said by a desponding pessimist that "There is nothing new, and nothing true, and nothing signifies," but I do not entirely agree with him; I believe that in what I am about to submit there is something new and true in the point of view from which I regard the matter; whether it signifies or not is for you to judge.

The universality of antagonism has not received the attention it seems to me to deserve, from the fact of the element of force, or rather of the conquering force, being mainly attended to, and too little note taken of the element of resistance unless the latter vanquishes the force, and then it becomes, popularly speaking, the force, and the former force the resistance.

There are propositions applying more or less to what I am going to say of some antiquity.

Heraclitus, quoted by Prof. Huxley, said: "War is the father and king of all things." Hobbes said war is the natural state of man, but his expressions have about them some little ambiguity. In Chapter I. of the "De Corpore Politico" he says, "Irresistible might in a state of nature is right," and "The estate of man in this natural liberty is war." Subsequently he says: "A man gives up his natural right, for when divers men having right not only to all things else, but to one another's persons, if they use the same there ariseth thereby invasion on the one part and resistance on the other, which is war, and therefore *contrary to the law of nature, the sum whereof consisteth in making peace.*" I can only explain this apparent inconsistency by supposing he meant "law of nature" to be something different from "the natural estate of man," and that the making peace was the first effort at contract, or the beginning of law; but then why call it the "*law of nature,*" where he says might is right? There is however some obscurity in the passage.

The Persian divinities, Ormuzd and Ahriman, were the supposed rulers or representatives of good and evil always at war, and causing the continuous struggles between human beings animated respectively by these two principles. Undoubtedly good and evil are antagonistic, but antagonism, as I view it, is as necessary to good as to evil, as necessary to Ormuzd as to Ahriman. Zoroaster's religion of a divine being, one and indivisible, but with two sides, is, to my mind, a more philosophical conception. The views of Lamarck on the modification of organic beings by effort, and the establishment of the doctrine of Darwin as to the effects produced by the struggle for existence and domination, come much nearer to my subject. Darwin has shown how these struggles have modified the forms and habits of organized beings, and tended to increased differentiation, and Prof. Huxley and Herbert Spencer have powerfully promoted and expanded these doctrines. To the latter we owe the happy phrase, "survival of the fittest," and Prof. Huxley has recently, in a paper in the *Nineteenth Century,* anticipated some points I should have adverted to as to the social struggles for existence. To be anticipated, and by a very short period, is always trying, but it is more trying when what you intended to say has been said by your predecessor in more terse and appropriate language than you have at your command.

I propose to deal with "antagonism" inductively, *i. e.*, with facts derived from observation alone, and not to meddle with spiritual matters or with consequences.

Let us begin with what we know of the visible universe, viz., suns, planets, comets, meteorites, and their effects. These are all pulling at each other, and resisting that pull by the action of other forces.

Any change in this pulling force produces a change, or, as it is called, perturbation, in the motion of the body pulled. The planet Neptune, as you know, was discovered by the effect of its pulling force on another planet, the latter being deflected from its normal course. When this pulling force is not counterbalanced by other forces, or when the objects pulled have not sufficient resisting power, they fall into each other. Thus, this earth is daily causing a bombardment of itself by drawing smaller bodies—meteorites—to it; 20,000,000 of which, visible to the naked eye, fall on an average into our atmosphere in each twenty-four hours, and of those visible through the telescope, 400,000,000 are computed to fall within the same period. Mr. Lockyer has recently given reasons for supposing the luminosity of nebulæ, or of many of them, is due to collisions or friction among the meteoritics which go to form them; but his paper on the subject is not yet published. You must get from Mr. Lockyer the details of his views. I hope he may, at one of these evening meetings, give you a *resume* of them from the place I now occupy.

What is commonly called centrifugal force does not come from nothing; it depends upon the law that a body falling by the influence of attraction, not upon, but near to, the attracting body, whirls round the latter, describing one of the curves known as conic sections. Hence, a meteorite may become a planet or satellite (one was supposed to have become so to this earth, but I believe the observations have not been verified); or it may go off in a parabola as comets do; or, again, this centrifugal force may be generated by the gradual accretion of nebulous matter into solid masses falling near to, or being thrown off from, the central nucleus, the two forces, centrifugal and centripetal, being antagonistic to each other, and the relative movements being continuous, but probably not perpetual. Our solar system is also kept in its place by the antagonism of the surrounding bodies of the Kosmos pulling at us. Suppose half of the stars we see, *i. e.*, all on one side of a meridian line, were removed, what would become of our solar system? It would drift away to the side where attraction still existed, and there would be a wreck of matter and a crash of worlds. It is very little known that Shakespeare was acquainted with this pulling force. He says, by the mouth of Cressida—

> "But the strong base and building of my love
> Is as the very center of the earth
> Drawing all things to it"—

a very accurate description of the law of gravitation, so far as this earth is concerned, and written nearly a century before Newton's time.

But in all probability the collisions of meteorites with the earth and other suns and planets are not the only collisions in space. I know of no better theory to account for the phenomena of temporary stars such as that which appeared in 1866, than that they result from the collision of non-luminous stars, or stars previously invisible to us. That star burst suddenly into light, and then the luminosity gradually faded, the star became more and more dim, and ultimately disappeared. The spectrum of it showed that the light was compound, and had probably emanated from two different sources. It was probably of a very high temperature. If this theory of temporary stars be admitted, we get a nebula of vapor or star dust again, and so may get fresh instances of the nebular hypothesis.

Let us now take the earth itself. It varies in temperature, and consequently the particles at or near its surface are in continuous movement, rubbing against each other, being oxidized or deoxidized, either immediately or through the medium of vegetation. This also is continuously tearing up its surface and changing its character. Evaporation and condensation, producing rain, hail, and storms, notably change it. Force and resistance are constantly at play. The sea erodes rocks and rubs them into sand. The sea quits them and leaves traces of its former presence by the fossil marine shells found now at high altitudes. Rocks crumble down and break other rocks or are broken by them; avalanches are not uncommon. The interior of the earth seems to be in a perpetual state of commotion, though only recurrent to our observation. Earthquakes in various places from time to time, and, doubtless, many beneath the sea of which we are not cognizant, nor of other gradual upheavals and depressions. Throughout it nothing that we know of is at rest, and nothing can move without changing the position of something else, and this is antagonism. Metals rust at its surface, and probably they or their oxides, chlorides, etc., are in a continuous state of change in the interior. Nothing that we know of is stationary. The earth as a whole seems so at first sight, but its surface is moving at the rate of some seventeen miles a minute at the equator; and standing at either of the poles—an experiment which no one has yet had an opportunity of trying—a man would be turned round his own axis once in every twenty-four hours, while the earth's motion round the sun carries us through space more than a million and a half of miles a day.

The above changes produce motion in other things. The earth pulls the sun and planets, and in different degrees at different portions of its orbit.

Before I pass from inorganic to organized matter I had better deal with what may perhaps strike you as the most difficult part of my subject, viz., light. Where, you may say, is there antagonism in the case of light? Light exercises its force upon such minute portions of matter that until the period of the discovery of photography, its physical and chemical effects were almost unknown. Such effects as bleaching, uniting some gases, and affecting the coloring matter of vegetables, were partly known, but little attended to; but photography created a new era. I shall advert to this presently. The theories of light, however, involved matter and motion. The corpuscular theory, as you well know, supposed that excessively small particles were emitted from luminous bodies, and traveled with enormous velocity. The undulatory theory, which supplanted it, supposed that luminous bodies caused undulations or vibrations in a highly tenuous matter called ether, which is supposed to exist throughout the interplanetary spaces and throughout the universe so far as we know it. Some suppose this ether to be of a specific character differing from that of ordinary gases, others that it is in the nature of a highly attenuated gas; but, whatever it be, it cannot be affected by undulations or vibrations without being moved, and when matter is moved by any force it must offer resistance to that force, and hence we get antagonism between force and resistance. Light also takes time in overcoming this resistance, *i. e.*, in pushing aside the ether. It travels no doubt at a good pace—about 190,000 miles in a second; but even at this rate, and without being particular as to a few millions of miles, it takes three years and a quarter to reach us from the star which, so far as we know, is the nearest to us, viz., α Centauri. The ether or whatever it may be called, tenuous as it is, is not unimportant, though it be not heavy. Without it we should have no light and possibly no heat, and the consequences of its absence would be rather formidable. I believe you have heard Dr. Tyndall on this subject. Supposing the visible universe to be as it is now supposed to be, *i. e.*, in no part a mere vacuum, there can be no force without resistance in any part of it.

But photography carries us further, it shows us that light acts on matter chemically, that it is capable of decomposing or forcing asunder the constituents of chemical compounds, and is therefore a force met by resistance. In the year 1856 I made some experiments, published in the *Philosophical Magazine* for January, 1857, which seemed to me to carry still further what I may call the molecular fight between light and chemical affinity, and among them the following. Letters cut out of paper are placed between two polished squares of glass with tin foil on the outsides. It is then electrized like a Leyden jar for a few seconds, the glasses separated, the letters blown off, and the inside of one of the glasses covered with photographic collodion. This is then exposed to diffuse daylight, and on being immersed in the nitrate of silver bath, the part which had been covered with the paper comes out dark, the remainder of the plate being unaffected. (This result was shown by the electric light lantern.) In this case we see that another imponderable force, electricity, invisibly affects the surface of glass in such a way that it conveys to another substance of definite thickness, viz., the prepared collodion, a change in the chemical relations of the substance (iodide of silver) pervading it, enabling it to resist that decomposition by light which but for some unseen modification of the surface of the glass plate it would have undergone, and no doubt the force of light being unable to effect its object was reflected or dispersed, and instead of changing its mode of motion in effecting chemical decomposition, it goes off on other business. The visible effect is in the collodion film alone. I have stripped that off, and the imprint remains on it, the surface of the glass being, so far as I could ascertain, unaffected. Thus in the film over the protected part, light conquers chemical affinity; in that over the non-protected part, chemical affinity resists and conquers light, which has to make an ignominious retreat. It is a curious chapter in the history of the struggles of molecular forces, and probably similar contests between light and chemical or physical attractions go on in many natural phenomena, some forms of blight and some healthy vegetable changes being probably dependent on the varying effects of light, and conditions, electrical or otherwise, of the atmosphere.

Let us now pass on to organic life. A blade of grass, as Burke, I believe, said as a figure of speech, is fighting with its neighbors. It is robbing them, and they are trying to rob it—no agreement or contract, simply force opposed to force. This struggle is good for the grass; if it got too much nutriment, it would become diseased. The struggle keeps it in health. The rising of sap in trees, the assimilation of carbon, the process of growth, the strengthening themselves to resist prevalent winds, and many other instances might be given, which afford examples of the internal and external struggles in vegetable life.

I will now proceed to consider animal life, and in this case I will begin with the internal life of animals, which is a continual struggle. That great pump, the heart, is continuously beating—that is, conquering resistance. It is forcing the blood through the arteries, they assisting in squeezing it onward. If they give way, the animal dies; if they become rigid and resist too much, the animal dies. There must be a regulated antagonism, a rhythmical pulsation, the very term involving force and resistance. That the act of breathing is antagonistic scarcely needs argument. The muscular action by which the ribs are made to open out and close alternately, in order to inhale and exhale air, and other physiological changes which I cannot here go into, necessitate a continuous fight for life. So with digestion, assimilation, and other functions, mechanical and chemical forces and resistances come into play.

Since this lecture was written, I have heard of a discovery made, I am informed, by Prof. Metschnikoff, and which has brought to light a singular instance of internal antagonism. He is said to have proved that the white corpuscles of the blood are permanent enemies of bacteria, and by inoculation will absorb poisonous germs, a recurrent war, as it appears, going on between them. If the corpuscle is the conqueror, the bacteria are swallowed up, and the patient lives. If the corpuscles are vanquished, the patient dies, and the bacteria live, at all events for a time. If the theory is founded, it affords a strong additional argument to the doctrine of internal antagonism. Possibly if there were no bacteria, and the corpuscles had nothing to do, it would be worse for them and the animal whom they serve.

Let us now consider the external life of animals. I will take as an instance, for a reason which you will soon see, the life of a wild rabbit. It is throughout its life, except when asleep (of which more presently), using exertion, cropping grass, at war with vegetables, etc. If it gets a luxurious pasture, it dies of repletion. If it gets too little, it dies of inanition. To keep itself healthy it must exert itself for its food; this, and perhaps the avoiding its enemies, gives it exercise and care, brings all its organs into use, and thus it acquires its most perfect form of life. I have witnessed this effect myself, and that is the reason why I choose the rabbit as an example. An estate in Somersetshire, which I once took temporarily, was on the slope of the Mendip Hills. The rabbits on one part of it, viz., that on the hill side, were in perfect condition, not too fat nor too thin, sleek, active, and vigorous, and yielding to their antagonists, myself and family, excellent food. Those in the valley, where the pasturage was rich and luxuriant, were all diseased, most of them unfit for human food, and many lying dead on the fields. They had not to struggle for life, their short life was miserable and their death early. They wanted the sweet uses of adversity—that is, of antagonism.

The same story may be told of other animals. Carnivora, beasts or birds of prey, live on weaker animals, weaker animals herd together to resist, or, by better chance of warning, to escape beasts of prey, while they, the herbivora, in their turn are destroying vegetable organisms.

I now come to the most delicate part of my subject,

* Lecture delivered at the Royal Institution, on April 20, by the Right Hon. Sir William R. Grove, F.R.S.—*Nature.*

viz., man (I include women of course!) Is man exempt from this continual struggle?

It is needless to say that war is antagonism. Is not peace so also, though in a different form? It is a commonplace remark to say that the idle man is worn out by *ennui*, *i. e.*, by internal antagonism. Kingsley's "Do-as-you-like" race—who were fed by a substance dropping from trees, who did no work, and who gradually degenerated until they became inferior to apes, and ultimately died out from having nothing to do, nothing to struggle with—is a caricature illustrative of the matter. That the worry of competition is nearly equivalent to the hardships and perils of military life seems proved to me by the readiness with which military life is voluntarily undertaken, ill as it is paid. If it were well paid, half our men would be in the military or naval service, and I am not sure that we should not have regiments of Amazons! The increased risk of life or limbs and the arduous nature of the work do not prevent men belonging to all classes from entering these services, little remunerative as they are. Others take the risks of traveling in the deserts of Africa or wintering in the polar regions, of being eaten by lions or frozen to death, of falling from a Swiss mountain or foundering in a yacht, in preference to a life of tranquility; and sportsmen elect the danger of endeavoring to kill an animal that can and may kill them, to shooting tame pheasants at a *battue* or patridges in a turnip field.

Then, in what is euphemistically called a life of peace, buyer and seller, master and servant, landlord and tenant, debtor and creditor, are all in a state of simmering antagonism, and the inventions and so-called improvements of applied science and art do not lessen it. Exercise is antagonism, at each step force is used to lift up our bodies and push back the earth; as the eminent Joseph Montgolfier said, that when he saw a company dancing, he mentally inverted his view and imagined the earth dancing on the dancers' feet, which it most unquestionably did. Indeed, his great invention of balloons was guessed at by his witnessing a mild form of antagonism between heat and gravitation. He, being a dutiful husband, was airing his wife's dresses, who was going to a ball. He observed the hot air from the fire inflated the light materials, which rose up in a sort of spheroidal form (you may some of you have noticed this form in dress!) This gave him the idea of the fire balloon, which, being a large paper maker at Annonay, he forthwith experimented on, and hence we got aerial navigation. This anecdote was told me by his nephew, M. Seguin, also an eminent man. Even what we call a natural death is a greater struggle than that which other animals go through, and is, in fact, the most artificial of all deaths. The lower animals, practically speaking, do experience a natural death, *i. e.*, a violent or unforeseen death. As soon as their powers decline to such an extent that they cannot take part in the struggle for existence, they die or are killed, generally quickly, and their sufferings are not protracted by the artificial tortures arising from the endeavors to prolong life.

Let us now pass from individuals to communities. Is there less antagonism now than of yore? Do the nations of Europe now form a happy family? Are the armaments of Continental nations, or is the navy of this country, less than in former years? The very expression "the Great Powers" involves antagonism.

As with wars and revolutions, so, as I have said, with regard to individuals, during our so-called peace, the fight is continuous among communities. If the water does not boil, it simmers. Not merely are there the struggles of poor against rich going on, but the battles for position and pre-eminence are constant. The subjugated party or sect seeks first for toleration, then for equalization, and then for domination.

We call contentment a virtue, but we inculcate discontent. A father reproaches his son for not exerting himself to improve his position, and at school and college and in subsequent periods of life efforts at advancement in the social scale are recommended. Individual antagonisms, class antagonisms, political, trading, and religious antagonisms, take the place of war. Can war exhibit a more vigorous and persistent antagonism than competition does? Take the college student with ruined health, take the bankrupt tradesman with ruined family, take the aspirants to fashion turning night into day, and preferring gas or electric light to that of the sun; there is, to be sure, some excuse for this, as we so rarely see the latter. But our very amusements are of a combative character—chess, whist, billiards, racing, cricket, football, etc. And in all these we, in common parlance, speak of *beating* our opponent.

Even dancing is probably a relic and reminiscence of war, and some of its forms are of a military character. I can call to mind only one game which is not combative, and that is the game you are in some sort now playing, viz., "patience," and with, I fear, some degree of internal antagonism!

Take, again, the ordinary incidents of a day's life in London, 15,000 to 20,000 cabs, omnibuses, vans, private carriages, etc., all struggling, the horses pushing the earth back and themselves forward, the pedestrians doing the same, but the horses compulsorily—they have not as yet got votes. The occupants of the cabs, vans, etc., are supposed to act from free will, but in the majority of cases they are as much driven as the horses. Insolvents trying to renew bills, rich men trying to save what they have got by saving half an hour of time. Imagine, if you can, the friction of all this, and add the bargaining in shops, the mental efforts in counting houses, banks, etc., and road repair, now a permanent and continuous institution. Take our railways, similar efforts and resistances. Drivers, signal men, porters, etc., and the force emanating from the sun millions of years ago, and locked up in the coal fields, as Stephenson suggested, now employed to overcome the inertia of trains and to make them push the earth in this or that direction, and themselves along its surface. Take the daily struggles in commerce, law, professions, and legislation, and sometimes even in science and literature. Politics I cannot enter upon here, but must leave you to judge whether there is not some degree of antagonism in this pursuit. In all this there is plenty of useful antagonism, plenty of useless—much to please Ormuzd and much to delight Ahriman, but of the two extremes, overwork or stagnation, the latter would, I think, do Ahriman's work more efficiently than the former. We cry peace when there is no peace. Would the world, however, be better if it were otherwise? Is the Nirvana a pleasing prospect? Sleep, though not without its troubles and internal antagonism, is our nearest approach to it, but we should hardly wish to be always asleep.

Shakespeare not only knew something about gravitation, but he also knew something about antagonism. He says, by the mouth of Agamemnon—

"Sith every action that hath gone before
Whereof we have record, trial did draw
Bias and thwart, not answering the aim,
And that unbodied figure of the thought
That gav't surmised shape."

In no case is the friction of life shown more than in the performance of "duty," *i. e.*, an act of self-resistance, a word very commonly used; but the realization of it is by no means so frequent. Indeed, faith in its performance so yields to skepticism that it is said that when a man talks of doing his duty he is meditating some knavish trick.

The words good and evil are correlative; they are like height and depth, parent and offspring. You cannot, as far as I can see, conceive the existence of the one without involving the conception of the other. In their common acceptation they represent the antagonism between what is agreeable or beneficial and what is painful or injurious.

An old anecdote will give us the notion of good and evil in a slenderly educated mind. A missionary having considered that he had successfully inculcated good principles in the mind of a previously untutored savage, produced him for exhibition before a select audience, and began his catechism by asking him the nature of good and evil. "Evil," the pupil answered, "is when other man takes my wife." "Right," said the missionary, "now give me an example of good." The answer was: "Good is when me takes other man's wife." The answer was not exactly what was expected, but was not far in disaccord with modern views among ourselves and other so-called civilized races. I don't mean as to running away with other men's wives. But we still view good and evil very much as affecting our own interests. At the commencement of a war each of the opposing parties view victory—*i. e.*, the destruction of their enemies—as good, and being vanquished as evil. Congregations pray for this. Statesmen invoke the God of battles. Those among you who are old enough will call to mind the Crimean war. Each combatant nation gives thanks for the destruction of the enemy, each side possibly believing that they respectively are in the right, but in reality not troubling themselves much about that minor question. We (unconsciously perhaps) "compound for sins we are inclined to by damning those we have no mind to." So in the daily life of what is called peace. The stage coach proprietor rejoiced when he had driven his rival off the road, railway directors and shareholders now do the same, so do publicans, shopkeepers, and other rivals. We are still permeated by the old notion of good and evil. But "antagonism," as I view it, not only comprehends the relation of good and evil, but, as I have said, produces both, and is as necessary to good as to evil. Without it there would be neither good nor evil. Judging of the lives of our progenitors from what we see of the present races of men of less cerebral development, we may characterize them as having been more impulsive than ourselves, and as having their joys and sorrows more quickly alternated. After the hunt for food, accompanied by privation and suffering, comes the feast to gorging. Their main evil was starvation, their good repletion. Even now the Esquimaux watches a seal hole in the bitter cold for hours and days, and his compensation is the spearing and eating the seal. The good is resultant upon and in the long run I suppose equivalent to the evil. These men look not back into the past and forward into the future as we do. We, by extending our thought over a wider area, are led to more continuing sacrifices, and aim at more lasting enjoyment in the result. The child suffers at school in order that his future life may be more prosperous. The man spends the best part of his life in arduous toil, physical or mental, in order that he may not want in his later years, or that his family may reap the benefit of his labor. Further-seeing men spend their whole lives on work little remunerative that succeeding generations may be benefited. The prudent man transmits health and wealth to his descendants, the improvident man poverty or gout. One main element of what we call civilization is the capability of looking further back into the past and further forward into the future; but, though measured on a different scale, the average antagonism and approximate equivalence appear to me to be the same.

Can we suppose a state of things either in the inorganic or the organic world which, consistently with our experience or any deduction drawn from it, would be without antagonism? In the inorganic world it would be the absence of all movement, or, what practically amounts to the same thing, movement of everything in the same direction, and the same relative velocity; for, as movement is only known to us by relation, movement where nothing is stationary or moving in a different direction or with a different velocity would be unrecognizable.

So in the organic but non-sentient world, if there were no struggle, no absorption of food, no growth, nothing to overcome, there would be nothing to call life. If, again, in the sentient world there were no appetites, no hopes—for both these involve discontent—no fear, no good or bad, what would life be? If fully carried out, is not a life without antagonism no life at all, a barren metaphysical conception of existence, or rather alleged conception, for we cannot present to the mind the form of such conception?

In the most ordinary actions, such as are necessary to sustain existence, we find, as I have already pointed out, a struggle more or less intense, but we also find a reciprocal interdependence of effort and result. The graminivorous animal is during his waking hours always at work, always making a small but continuous effort, selecting his pastures, cropping vegetables, avoiding enemies, etc. The carnivora suffer more in their normal existence; their hunger is greater, and their physical exertion when they are driven by hunger to make efforts to obtain food is more violent than with the herbivora, if they capture their prey by speed or battle, or their mental efforts are greater if they capture it by craft. But then their gratification is also more intense, and thus there is a sort of rough equation between their pain and their pleasure—the more sustained the labor, the more permanent is the gratification.

As, with food or exercise, deficiency is as injurious in one as is excess in another direction, so, as affecting the mind of communities, as I have stated it to be with individuals, the effect of a life of ease and too much repose is as much to be avoided as a life of unremitting toil. The Pitcairn Islanders, who managed in some way to adapt their wants to their supply and to avoid undue increase of population, are said never to have reached old age. In consequence of the uneventful, unexcited lives they led, they died of inaction, not from deficiency of food or shelter, but of excitement. They should have migrated to England! They died as hares do when their ears are stuffed with cotton, *i. e.*, from want of anxiety. We have hope in our suffering, and in the mid-gush of our pleasures something bitter surges up.

"We look before and after, and pine for what is not,
Our sincerest laughter with some pain is fraught,
Our sweetest songs are those which tell of saddest thought."

The question may possibly occur to you, Have we more or less antagonism now than in former times? We certainly have more complexity, more differentiation, in our mental characteristics, and probably in our physical, so far as the structure of the brain is concerned; but is there less antagonism? With greater complexity come increased wants, more continuous cares. Higher cerebral development is accompanied with greater nervous irritability, with greater social intricacies—we have more frequent petty annoyances, and they affect us more. With all our so-called social improvements, is there not the same struggle between crime and its repression? If we have no longer highway robberies, how many more cases of fraud exist, most of it not touched by our criminal laws? As to litigation, I am perhaps not an impartial judge, but it seems to me that if law were as cheap as is desired, every next door neighbor would be in litigation. It would seem as if social order had never more than the turn of the scale which is necessary to social existence in its favor when contrasted with the disorganizing forces. Without that there would be perpetual insurrections and anarchy. But though antagonism takes a different form, it is still there. Are wars more regulated by justice than of yore? I venture to doubt it, though probably many may disagree with me. National self-interest or self-aggrandizement is, I think, the predominant factor, and is frequently admittedly so. I also doubt if the old maxim, "If you wish for peace, prepare for war," is of much value. Large armaments and improvements in the means of destruction (whose inventors are more thought of than the discoverers of natural truths) are as frequently the cause of war as of its prevention. Are wars less sanguinary with 100 ton guns than with bows and arrows? I cannot enter into statistics on this subject, but a sensible writer who has, viz., Mr. Finlaison, came to the conclusion that wars ceased now as anciently, not in the ratio of the improvements in killing implements, but from exhaustion of men or means. Wars undoubtedly occur at more distant intervals, or the human race would become extinct. Probably the largely increased competition supplies their place: we fight commercially more and militarily less. It is a sad reflection that man is almost the only animal that fights, not for food or means of life or of perpetuating its race, but from motives of the merest vanity, ambition, or passion. War is, however, not wholly evil. It develops noble qualities—courage, endurance, self-sacrifice, friendship, etc.—and tends to get rid of the silly incumbrances of fashion and ostentation. But do the much bepraised inventions of peace bring less antagonism? Consider the enormous labor and waste of time due to competition in the advertising system alone. Paper making, type founding, printing, pasting, posting, or otherwise circulating, sandwich men, etc., all at work for purposes which I venture to think are in great part useless; and those who might add to the productiveness of the earth, or to the enriching our knowledge, are helping to extend the limits of the black country, and wasting their time in interested self-laudation. And the consumer pays the costs. "Buy my clothing, which will never wear out." "Become a shareholder in our company, which will pay cent per cent." "Take my pills, which will cure all diseases," etc. These eulogies come from those highly impartial persons the advertisers, all promising golden rewards, but, as with the alchemists, on condition that gold be paid in advance for their wares; and the silly portion of the public, no small body, take them at their word. Though you may not fully agree in this my anathema of the advertising system, and though there may be some small modicum of good in it, I think you will agree that it affords a notable illustration of antagonism. If I were a younger man, I think I should go to Kamchatka to avoid the penny post; possibly I should not be satisfied when I got there. Civilization begins by supplying wants, and ends by creating them, and each supply for the newly created want begets other wants, and so on "*toties quoties*."

As far as we can judge by its present progress, mankind seems tending to an automatic state. The requirements of each day are becoming so numerous as to occupy the greater portion of that day; and when telegrams, telephones, electromotion, and numerous other innovations which will probably follow these, reach their full development, no time will be left for thought, repose, or any spontaneous individual action. In this mechanical state of existence, in times of peace, extremes of joy and sorrow, of good and evil, will become more rare, and the necessary uniformity of life will reduce passion and feeling to a continuous petty friction. The converse of the existence contemplated by the Stoics will be attained, and, instead of a life of calm contemplation, our successors will have a life of objectless activity. The end will be swallowed up in the means. It will be all pursuit and no attainment. Is there a *juste milieu*, a point at which the superfluous *commoda vitæ* will cease? None probably would agree at where that point should be fixed, and the future alone can show whether the human race will emancipate itself from being, like Frankenstein, the slave of the monster it has created. In the cases I have given as illustrations—and many more might be adduced—the evil resulting from apparently beneficial changes is not a mere accident: it is as necessary a consequence as reaction is a consequence of action. In

the struggle for existence or supremacy, inevitable in all social growths, the invention, enactment, etc., intended to remedy an assumed evil will be taken advantage of by those for whom it is not intended; the real grievance will be exaggerated by those having an interest in trading on it, and the remedy itself will have collateral results not contemplated by those who introduce the change. I could give many instances of this by my own experience as an advocate and judge, but this would lead me away from my subject. Evils, indeed, result from the very change of habit induced by the alleged improvement. The carriage which saves fatigue induces listlessness, and tends to prevent healthy exercise. The knife and fork save the labor of mastication, but by their use there is not the same stimulus to the salivary glands, not the full healthy amount of secretion, whereby digestion suffers; there is not the same exercise of the teeth whereby they are strengthened and uniformly worn, as we see in ancient skulls. It seems not improbable that their premature decay in civilized nations is due to the want of their normal exercise by the substitution of the knife and fork and stew pan. According to the evolution theory, our organs have grown into what they are, or ought to be, by long use, and the remission of this tends to irregular development or atrophy. Every artificial appliance renders nugatory some pre-existing mode of action, either voluntary or involuntary; and as the parts of the whole organism have become correlated, each part being modified by the functions and actions of the others, every part suffers more or less when the mode of action of any one part is changed. So with the social structure, the same correlation of its constituent parts is a necessary consequence of its growth, and the change of one part affects the well-being of other parts. All change, to be healthy, must be extremely slow, the defect struggling with the remedy through countless but infinitesimally minute gradations.

Lastly, so the forms of government give us any firm ground to rest upon as to there being less undue antagonism in one than in another form. Whether it is better to run a risk of, say, one chance in a thousand or more of being decapitated unjustly by a despot, or to have what one may eat or drink, or whom one may marry, decided by a majority of parish voters, is a question on which opinions may differ, but there is abundant antagonism in either case.

Communism, the dream of enthusiasts, offers little prospect of ease. It involves an unstable equilibrium, *i. e.*, it consists of a chain of connection where a defect in one link can destroy the working of the whole system, and why the executive in that system should be more perfect than in others I never have been able to see. Antagonism, on the other hand, tends to stability. Each man working for his own interests helps to supply the wants of others, thus ministering to public convenience and order, and if one or more fail the general weal is not imperiled.

You may ask, Why this universal antagonism? My answer is, I don't know. Science deals only with the How, not with the Why. Why does matter gravitate to other matter, with a force inversely as the square of the distance? Why does oxygen unite with hydrogen? All I can say is that antagonism is, to my mind, universal, and will, I believe, some day be considered as much a law as the law of gravitation. If matter is, as we believe, everywhere, even in the interplanetary spaces, and if it attracts and moves other matter, which it apparently must do, there must be friction or antagonism of some kind. So with organized beings, Nature only recognizes the right, or rather the power, of the strongest. If twenty men be wrecked on a secluded island which will only support ten, which ten have a right to the produce of the island? Nature gives no voice, and the strongest take it. You may further ask me, *Cui bono?* what is the use of this disquisition? I should answer, If the views be true, it is always useful to know the truth. The greatest discoveries have appeared useless at the time. Kepler's discovery of the relations of the planetary movements appeared of no use at the time; no one would now pronounce it useless. I can, however, see much probable utility in the doctrine I have advocated. The conviction of the necessity of antagonism, and that without it there would be no light, heat, electricity, or life, may teach us (assuming free will) to measure effort by the probable result and to estimate the degree of probability. It may teach us not to waste our powers on fruitless objects, but to utilize and regulate this necessity of existence; for, if my views are correct, too much or too little is bad, and a due proportion is good (like many other useful things, it is best in moderation), to accept it rather as a boon than a bane, and to know that we cannot do good without effort—that is, without some suffering.

I have spoken of antagonism as pervading the universe. Is there, you may ask, any limit in point of time or space to force? If there be so, there must be a limit to antagonism. It is said that heat tends to dissipate itself, and all things necessarily to acquire a uniform temperature. This would in time tend practically, though not absolutely, to the annihilation of force and to universal death; but if there be evidence of this in our solar system and what we know of some parts of the universe, which probably is but little, is there no conceivable means of reaction or regeneration of active heat? There is some evidence of a probable zero of temperature for gases as we know them, *i. e.*, a temperature so low that at it matter could not exist in a gaseous form; but passing over gases and liquids, if matter becomes solid by loss of heat, such solid matter would coalesce, masses would be formed, these would gravitate to each other, and come into collision. It would be the nebular hypothesis over again. Condensation and collisions would again generate heat; and so on *ad infinitum*.

Collisions in the visible universe are probably more frequent than is usually supposed. New nebulæ appear where there were none before, as recently in the constellation of Andromeda. Mr. Lockyer, as I have said, considers that they are constant in the nebulæ; and if there be such a number of meteorites as are stated to fall daily into the atmosphere of this insignificant planet, what numbers must there be in the universe? There must be a sort of fog of meteorites, and this may account, coupled with possibly some dissipation of light or change of it into other forces, for the smaller degree of light than would be expected if the universe of stellar bodies were infinite. For if so, and the stars are assumed to be of an equal average brightness, then if no loss or obstruction, as light decreases as the square of the distance and stars increase in the same ratio, the night would be as brightly illuminated as the day. We are told that there are stars of different ages—nascent, adolescent, mature, decaying, and dying; and when some of them, like nations at war, are broken up by collision into fragments or resolved into vapor, the particles fight as individuals do, and like them end by coalescing and forming new suns and planets. As the comparatively few people who die in London to-night do not affect us here, so in the visible universe one sun or planet in a billion or more may die every century and not be missed, while another is being slowly born out of a nebula. Thus worlds may be regenerated by antagonism without having for the time more effect upon the Kosmos than the people now dying in London have upon us. I do not venture to say that these collisions are in themselves sufficient to renew solar life; time may give us more information. There may be other modes of regeneration or renewed activity of the dissipated force, and some of a molecular character. The conversion of heat into atomic force has been suggested by Mr. Crookes. I give no opinion on that, but I humbly venture to doubt the mortality of the universe.

Again, is the universe limited? and if so, by what? Not, I presume, by a stone wall! or if so, where does the wall end? Is space limited, and how? If space be unlimited, and the universe of suns, planets, etc., limited, then the visible universe becomes a luminous speck in an infinity of dark vacuous space, and the gases, or at all events the so-called ether, unless limited in elasticity, would expand into this vacuum—a limited quantity of ether into an infinite vacuum! If the universe of matter be unlimited in space, then the cooling down may be unlimited in time. But these are perhaps fruitless speculations. We cannot comprehend infinity, neither can we conceive a limitation to it. I must once more quote Shakespeare, and say in his words, "It is past the infinite of thought." But whatever be the case with some stars and planets, I cannot bring myself to believe in a dead universe surrounded by a dark ocean of frozen ether.

Most of you have read "Wonderland," and may recollect that after the Duchess has uttered some ponderous and enigmatical apophthegms, Alice says, "Oh!" "Ah," says the Duchess, "I could say a good deal more if I chose." So could I; but my relentless antagonist opposite (the clock) warns me, and I will only add one more word, which you will be glad to hear, and that word is—finis.

A CAVALRY PRECAUTION.

The British War Office have issued a circular inviting owners of twenty horses and upward, within the metropolitan area, to register such a number of horses as they would be prepared to sell to the government on the occasion of a great national emergency. Ten shillings per horse registered will be paid annually as retaining fee. Only serviceable horses of from five to ten years of age and from 15 hands to 16 hands 2 inches high will be registered. Officers appointed by the secretary of state will inspect the class of horse owners propose to register, on their premises, at least once a year, after which the final agreement will be made as to prices with the proprietors. The government are prepared to agree to pay in case of taking the animals a price which would represent (*a*) what it would cost to replace them, (*b*) the estimated loss which might accrue pending their being replaced. As it is evident that the amount of (*a*) and (*b*) above would vary in proportion to the number of horses required by the government, the prices to be agreed upon should, it is considered, be based on a sliding scale. The following particulars should be given by owners of horses: (1) The number of horses of the description defined they are prepared to hold at the disposal of the government in the event of their being required under an emergency; (2) the price per horse they consider should be given by the government in the event of their horses being impressed—(*a*) if a quarter of the registered number be taken; (*b*) if one-half be taken; (*c*) if three-quarters be taken; (*d*) if the whole be taken. Varying rates can be named where owners have more than one class in possession.

THE FIRST BALLOON VOYAGE.

The editor of *La Nature* has recently come into possession of an unpublished letter, written in 1783, by Benjamin Franklin to Sir Joseph Banks, on the subject of the first ascent in a free balloon, made by Pilatre de Rosier and the Marquis of Arlandes, at the Muette garden, on the 21st of November, 1783.

Franklin was residing at Passy at the time, and writes to Banks as follows:

Dear Sir: Your friendly letter of the 7th of March has been received by me, and I am glad to see that my account of the aerostatic experiment seems to have interested you. But as there has already been published, and there is yet to be published, in advance of your memoir, a completer report on the construction and handling of this apparatus, and as extracts from that might be made in a preciser and consequently a more satisfactory manner, I think it preferable not to print my letters. I say this in answer to your question, for I certainly did not write them with a view to publication.

I was apprised by Mr. Faujas de Saint-Fond yesterday that a long expected work on this subject is to appear in a few days. I shall send you a copy of it.

I inclose a copy of the report on the experiment made yesterday in the Queen's garden at the Muette palace,

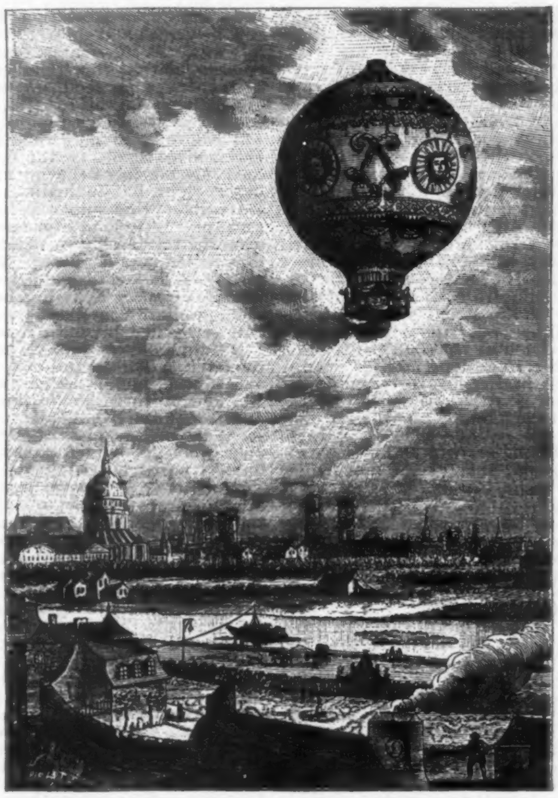


Fig. 1.—THE FIRST BALLOON ASCENSION.—VIEW OF FRANKLIN'S TERRACE AT PASSY.

the present residence of the Dauphin, and at which I was present, for my residence is very near by. As this document was got up in haste, and might appear obscure to you in some places, I shall add a few explanatory observations. The balloon experimented with at Muette was larger than the one sent up at Versailles with a sheep, etc. Its appendage was open, and to the center of it there was fixed a sort of lattice-work basket in which small fagots and bundles of straw were lighted. The air being rarefied in thus passing through the flames, inflated and filled the balloon. The persons who entered the osier gallery attached outside near the appendage each had in front of him an aperture that allowed him to throw bundles of straw into the fireplace in order to keep up the fire and keep the balloon full. When the latter passed over our heads, we could see the fire, of which there was a considerable quantity. In measure as the flames diminish, the rarefied air becomes cool and condenses, the size of the balloon diminishes, and it begins to descend. If the persons in the gallery see that they are going to descend in an unfavorable place, they can, by throwing in some straw, quicken the flames and rise again, and the wind will carry them further along.

The machine, impelled by the wind, took its course over one of the garden walks, that is to say, against the trees of one of the avenues. The gallery got caught in the upper branches of these trees, which had just been trimmed and were very stiff, while the body of the balloon leaned over and seemed as if it must turn upside down. I was then anxious as to the fate of the aeronauts, fearing lest I might see them fall out or be burned, for, since the balloon was no longer upright, it was possible for the flames to set fire internally to the fabric, which hung just above. But, by means of ropes, which were still fastened to it, it was soon possible to right the balloon, and cause it to descend and to bring it back in place. It was much damaged, however.

Hovering over the Horizon.—When they had as-

cended to the desired height, the travelers made less fire and allowed the machine to move horizontally with the wind, which they felt but slightly, as they were going with it, and so swiftly. They say that they had a magnificent view of Paris and its vicinity, the course of the river, etc. But at one moment they were lost, no longer knowing over what point they were situated, and they found out only on spying the dome of the Invalides. Probably while they were busy keeping up the fire the machine had turned, and, as the French say, they were *desorientes*.

There was a great throng of people of rank in the Muette garden. Every one was delighted that everything passed off so merrily, and applauded by a clapping of hands; but, at the same time, great anxiety was felt for the safety of the travelers.

A great crowd in Paris saw the balloon pass, but no one knew that there were men in it, since it had risen so high they could not be perceived.

Developing the Gas.—This, in good English, signifies burning more straw; for, although there seems to be a desire to make a mystery of the kind of air with which the balloon is inflated, I suppose it is simply hot smoke or common rarefied air, though I may be deceived.

Having still in their gallery two-thirds of their supply of fuel (that is, straw), of which they took a large quantity, it is fortunate that, in the precipitancy of so hazardous an experiment, and in consequence of a false maneuver, the straw did not take fire, although each aeronaut had taken the precaution to provide himself with a pail of water. One of these bold scientists, the Marquis of Arlandes, did me the honor to call upon me on the very evening after the experiment, with Mr. De Montgolfier, the skillful inventor. I was happy to see him safe and sound. He told me that they had landed gently without a shock, and that the balloon had been but very slightly damaged.

This method of inflating a balloon with hot air is expeditious and cheap, and answers for many purposes, as, for example, for lifting an officer in order to allow him to observe an army or the works of the enemy, to put himself in communication with a besieged city, to exchange signals with distant places, etc.

The other method, which consists in inflating a balloon with hydrogen gas and closing it, is a long and very expensive operation. Nevertheless, we are to see an ascension of this kind in a few days. The balloon is a globe 26 feet in diameter, the sides of which are of red and white silk of the prettiest effect. A very elegant triumphal car will be suspended from it, and this will be occupied by the two Robert brothers, men of great merit, who constructed it in concert with Mr. Charles. There is room in the car for a small table, which they will place between them, and on which they will be able to keep their journal, take note of all their observations, and of the state of their thermometer, barometer, hygrometer, etc., and this they will be more easily able to do, in that they have no fire to keep up. They say, too, that they have a device that will allow them to descend at will, but I do not know what it is. It is said that the cost of this machine, inflation included, will exceed ten thousand pounds.

As this balloon, which is but 26 feet in diameter, is inflated with gas ten times lighter than common air, it can raise a much greater weight than the other, which, vastly larger, was inflated with air that could scarcely have been twice lighter. On the whole, the great size of one of these machines for so short an experiment, and the great expense of inflating the other, will greatly interfere with the use of these inventions, until chemistry has found a means of producing a light air at less cost. But the rivalry between the two parties is so great that improvement in the construction and handling of balloons has already made great progress, and no one can say how far it will go. It is but a few months ago that the idea of seeing scientists rising on a bag of smoke would have seemed as impossible and ridiculous as to see witches rising in the air on a broom handle. These machines are always submitted to currents of air. Perhaps mechanics will find a means of permitting them to move progressively in calm weather and to make slight head against the wind.

I am sorry that such experiments are totally neglected in England, where mechanical genius is so powerful, and I would like to see the same emulation between the two nations as that which exists here between the two parties. Your scientists seem to be too timid. In this country we are not afraid to have any one laugh at us. If we do a senseless thing, we are the first to make fun of it, and we are as satisfied with a witticism or a good song that well ridicules the failure of a project as we would be with its success.

It does not seem to me to be good reasoning to refuse to pursue a new experiment calculated to increase the power of man over matter, as long as we have not been able to ascertain the use to which such power will have been able to be applied. When we have learned how to use it, we ought to hope to find an application for it some day or other, as man has done for magnetism and electricity, which, at first, were subjects for amusement.

This Muette experiment is certainly not insignificant. It may have consequences of which no one can foresee the importance. We ought not to allow pride to stop our progress.

Beings of a condition superior to our own have not disdained to make and send forth balloons, otherwise we should never have enjoyed the light of those glorious bodies that regulate our days and nights, and should not have had the pleasure either of revolving around the sun ourselves on the balloon that we now inhabit.

Please believe me, my dear sir, with sentiments of great and sincere esteem, your very obedient and very humble servant,

B. FRANKLIN.

FIG. 2.—BENJAMIN FRANKLIN.

IPECAC SPRAY IN BRONCHIAL TROUBLES.

THE success attending the use of a certain nostrum as a spray remedy for chronic bronchitis and other diseases of the throat and respiratory organs has led to attempts to make out its composition. Although some uncertainty was at first produced by conflicting statements as to its physical properties, which favored the suspicion that it was not always uniform in its composition, Dr. Murrell states that some preliminary trials speedily demonstrated that if the specific were not ipecacuanha wine, nevertheless that preparation entered largely into its composition (*Med. Press and Circ.*, April 21, p. 423). It was found that if ipecacuanha wine of full strength, or diluted with an equal quantity of water, or an alcoholic preparation of the same strength, be applied by means of a small steam vaporizer or the ordinary hand ball spray apparatus, it is capable of affording relief to congested and irritated bronchial mucous membranes. Dr. Murrell describes some cases where this ipecacuanha spray was used with great benefit in bronchial catarrh, chronic bronchitis, winter cough, fibroid phthisis, and congestion of the vocal chords. The best results were obtained by using the spray for ten minutes three or four times a day. The spray should always be warm, and the patient should not go out for some minutes after an inhalation.—*Pharmac. Journal.*

THE SPECIAL DIETS IN VARIOUS NERVOUS DISEASES.

By CHARLES L. DANA, M.D., New York City.

Diet of Brain Workers.—When persons train for athletic sports, the diet is mainly a nitrogenous and rather a dry one. For those training for mental work, and for brain workers in general, the best diet is also a nitrogenous one, but it should contain also considerable fat and should not be dry. Water should be drunk plentifully, while the total amount of food should be a little less than when severe muscular exercise is taken. The best foods are: meats, fish, eggs, milk, buttermilk, green vegetables, and stale bread with plenty of butter. If there is a tendency to constipation, farinaceous foods and green vegetables may be made the prominent articles of diet in one of the daily meals, and stewed fruit and some alkaline water added.

The drinks of brain workers should be mainly plain and alkaline waters. "Tea and coffee are for scholars, wine for artists," according to Moleschott, and these substances can be taken in moderation by most brain workers without harmful results. They may even secure an increased capacity for work.

Some brain workers have been tremendous feeders. Goethe was an immense eater; so were Samuel Johnson and William Wordsworth. Peter the Great ate only two meals daily, but these were very hearty, and his daily consumption of alcohol was, on an average, four bottles of beer, four of wine, and from one to two bottles of brandy.

Diet in Chronic Functional Nervous Diseases.—In persons of a sensitive and irritable nervous system, those who are classed popularly as "nervous," neurasthenic or hysterical, the same rules as to a nitrogenous diet, plus as much fat as can be digested, apply. There is a class of nervous persons who of themselves find that they cannot take anything sweet without producing headaches, rheumatic pains, and dyspeptic symptoms. These persons should live on meats, fish with plenty of butter, oysters, cream and milk with soda water, the yolk of an egg with sherry. Beef tea with the white of an egg or some peptonoids forms a very nutritious dish. It has been the canon of medicine for many years that animal food must be the soul of the neurotic's diet.

Most nervous persons find in addition that green vegetables like spinach agree very well with them. Stale bread can be taken twice a day freely, plenty of butter being used upon it. The dietetic breads from which the starch has been removed are sometimes useful, but are, as a rule, unpalatable and soon cause disgust.

When a rigid diet is to be laid down, there is no better list for nervous invalids than in the following:

Beef, and its preparations;
Mutton and lamb;
Fowl;
Fish, boiled or broiled;
Oysters;
Milk;
Butter;
Eggs, raw or soft-boiled;
Graham bread and gluten bread;
Spinach;
Stewed fruits slightly alkalinized.

Nervous patients, especially hysterical patients, should not use alcohol at all. Tea and coffee can be taken in very moderate amounts. The various mineral waters may be used with impunity, but none of them have much effect in relieving nervousness or curing the nervous temperament.

Milk Cure.—An exclusive milk diet is indicated in some forms of hysteria, hypochondriasis and neurasthenia accompanied with dyspepsia.

Karell's method is to give four to eight ounces of warm skim milk at 8 A. M., 12 M., 4 P. M., and 8 P. M. The amount is gradually increased.

Dry Cure, Grape Cure.—The so-called dry cure, the grape cure, and the mineral water cures are not indicated in cases of chronic functional nervous disease. A possible exception to the last rule is where the nervous symptoms are due directly to diabetes or lithæmia.

Diet in Hypochondriasis.—An excessive meat diet will sometimes bring on hypochondriasis, and in this condition the ordinary rules for nervous invalids are to be changed. Hypochondriacs must be fed largely upon vegetable food, which distends the colon and causes it to empty itself. When hypochondriasis is brought on by a meat diet, it is cured by porridge and green vegetables.

Diet in Epilepsy.—In epilepsy the character of the diet must be determined by the age and circumstances of the case. As a rule the diet should be fatty, farinaceous, fishy, and vegetable, meats being given in minor portion. The colon is often apparently inactive, and it

must be thoroughly emptied daily by the use of stewed fruits, porridges, green vegetables, Graham bread, and such medicinal or mechanical measures as may be required. The fats to be used are sweet oil, cream, butter, and cod liver oil. The meals, in younger patients, should be light, and should be eaten at regular intervals, five being taken daily when the appetite is ravenous, as is often the case.

Diet in the Chronic Schleroses.—In chronic schlerotic conditions of the spinal cord, such as locomotor ataxia, lateral or transverse myelitis, a diet of pure myosin and water has been recommended in some quarters very highly. The myosin is obtained by pounding steak with a dull-edged knife or by specially made choppers until the fibrous tissue is removed and the myosin obtained in the form of a pulp. This is made into balls and broiled. The patient lives on this food exclusively for some time, and drinks large amounts of hot water. Flesh is lost, the urine becomes clear and of rather high specific gravity, and amelioration in the pains and motor symptoms occur, due probably to the relief of dyspeptic complications.

Diet in the Chronic Central Degenerative Diseases.—In the chronic degenerative diseases, such as progressive muscular atrophy, bulbar paralysis, and ophthalmoplegia externa, no studies of the effect of special diets have been made so far as I am aware. I should expect, however, that a systematic overfeeding with fatty and nitrogenous foods would be indicated. Such diseases are a phthisis of the central gray matter, and might be benefited if treated in the same way as phthisis of other organs.

Composition of Nervous System.—One word, finally, regarding the chemical composition of nervous tissue and the popular conception respecting fish as a nerve food.

The nervous system has the following composition :

	Gray matter.	White matter.
Water	81·6	68·4
Solids	18·4	31·6

The solids consist of—

Albuminous bodies	55·4	24·7
Lecethin	17·2	9·9
Cerebrin	0·5	9·5
Cholesterin and fats	18·7	51·2
Substances resoluble in ether	6·2	3·3
Salts	1·5	0·5
	100	100

The salts consist of—

Potassium	32·42
Phosphoric acid	47·80
Sodium chloride	10·69
Magnesium	1·23
Calcium	0·72
Silica	0·42
Ferri phosphate	1·23
Sulphuric acid	0·75

As lecethin and cerebrin are considered to be bodies allied to fats, it will be seen that the solids of nervous tissue are about equally divided between nitrogenous and fatty bodies, the gray matter has a preponderance of albuminous, the white matter a preponderance of fatty constituents. Of the salts, phosphoric acid and its compounds make up nearly one-half, while potassium and sodium come next in amount.

Fish as Nerve Food.—Now, fish on the average has less salts, less fat, and more water than beef or meats generally, and hence if it is good in nervous disorders, it is not because of its peculiar composition, but because of its digestibility.

	Comp. of fat beef.	of white fish.	of salmon.
Water	51·0	78·0	77·0
Albumen	14·8	18·1	16·1
Fat	28·8	2·9	5·5
Salts	4·4	1·0	1·4

—*Journal of Reconstructives.*

THE MAYAS.

THE Garden of Eden is given a new location—in Central America—by Mme. Alice Le Plongeon, who with her husband, Dr. Le Plongeon, the eminent man of science, spent fourteen years in Yucatan, studying the antiquities of that country. Mme. Le Plongeon is also a firm believer in the submerged continent Atlantis, which Ignatius Donnelly wrote about before he began to annihilate Shakespeare. She says that among the manuscripts of the Mayas, the prehistoric inhabitants of Yucatan, is an account of the sinking of Atlantis, which once joined America to the western coast of Africa and Europe.

Other Maya writings give us, she asserts, the whole history of the intellectual development of the human family, free from all priestly or philosophic tinkering. The palaces and temples of the ancient race are situated in almost inaccessible forests, and the Spaniards are worse than indifferent in respect to archæological researches. They are unwilling to have their land disturbed for the sake of digging up a few more antiquities. Mme. Le Plongeon hopes that when her husband's book about Yucatan appears, as it will shortly, wide interest will be awakened in the matter of further investigations. The two explorers brought back with them to New York 2,000 photographs of the prehistoric edifices, and hundreds of drawings and models. Among the latter is a representation of the mausoleum of King Caw, the first ruler of the Mayas.

Mme. Le Plongeon thinks that this could be reproduced exactly in Central Park, forming an object lesson in the religion and customs of the race. She became interested in the old civilizations of Central America from her study of the relics in the British Museum, and went from London to Yucatan at the age of nineteen, just after her marriage. She learned Spanish and the Maya tongue, which she says is very much like Greek, and which is still spoken by the natives. Making due allowance for the exaggerations caused by her enthusiasm, the field in which she and her husband have been working is a valuable one, and they should receive encouragement from rich people interested in archæological matters.—*Springfield Republican.*

THE HOME OF THE ARYANS.

AFTER the discussion over the original home of the Aryan race, in which Geiger has placed it in Germany, Penka in Scandinavia, Poesche in Southwestern Germany, Lomaschek in Eastern Europe, and Canon Taylor in Northern Europe among the Finnic races, with which he would make the proto-Aryans identical,* Prof. Max Muller comes out with a book claiming that his first position was correct. According to him, the home of the Indo-Germanic nations was somewhere in the interior of Asia, and probably in the vicinity of the upper course of the Oxus, whence, at a remote period of antiquity, the Indri and Iranian peoples migrated southeastward, toward Hindostan and Persia, and the Hellenic, Italic, Celtic, Teutonic, and Slavic northwestward, spreading over Europe.

REDUCING OBESITY.—The Detroit *Lancet* describes the four plans for reducing obesity: The eating of nothing containing starch, sugar, or fat, called the Banting system; the eating of fat, but not sugar or starch, called the German Banting; the wearing of wool, and sleeping in flannel blankets instead of sheets, or the Munich system; not eating and drinking at the same time, or rather the allowing of a couple of hours to intervene between eating and drinking, the Schweninger system.

* SUPPLEMENT, No. 629, page 10054.

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